

EDN[®]

SPECIAL ISSUE:

Military electronics

Military relays

ECL-programmable
gate arrays and PLDsTroubleshooting
analog circuits—Part 7

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

P0787701 (9006) 002/ 97

T. MAHER
DETECTION SYSTEMS

BOX 397

BAYSWATER
AUSTRALIA

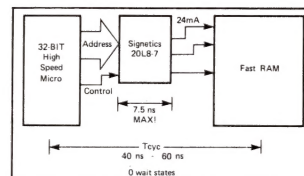
3153

Special Report Real-time Ada

"Vroom!"

Turbocharge your memory for zero wait state design with Signetics fast 7.5ns PAL[®]-type devices.

Vroom! Now you can get the zero wait state performance that will allow memory to keep pace with the new ultra-fast microprocessors. And you won't have to pay top price for your memory to do it!



7.5ns PAL-type device improves system performance.

Vroom! Boost system speed, lower memory cost. Signetics offers the fastest (7.5ns) PAL-type devices for high-speed decoding. Now you can design with slower, less expensive, more available memory devices and still enhance system speed. And all Signetics PLDs are easily supported by ABEL, CUPL or our powerful AMAZE design software.

7.5ns 20-pin		7.5ns 24-pin	
PLUS16L8-7	PLUS16R6-7	PLUS20L8-7	PLUS20R6-7
PLUS16R4-7	PLUS16R8-7	PLUS20R4-7	PLUS20R8-7

Vroom! We've got the guts! That's right, we have those essential PLDs you need to improve total system performance. Programmable Macro Logic, Logic Arrays, Logic Sequencers and our PAL-type products that cut system cost while boosting system speed.

Turbocharge your memory now! Call Signetics at (800) 227-1817, ext. 985D, for a free High-Speed Decoder Handbook. For surface mount and military product availability, contact your local Signetics sales office.

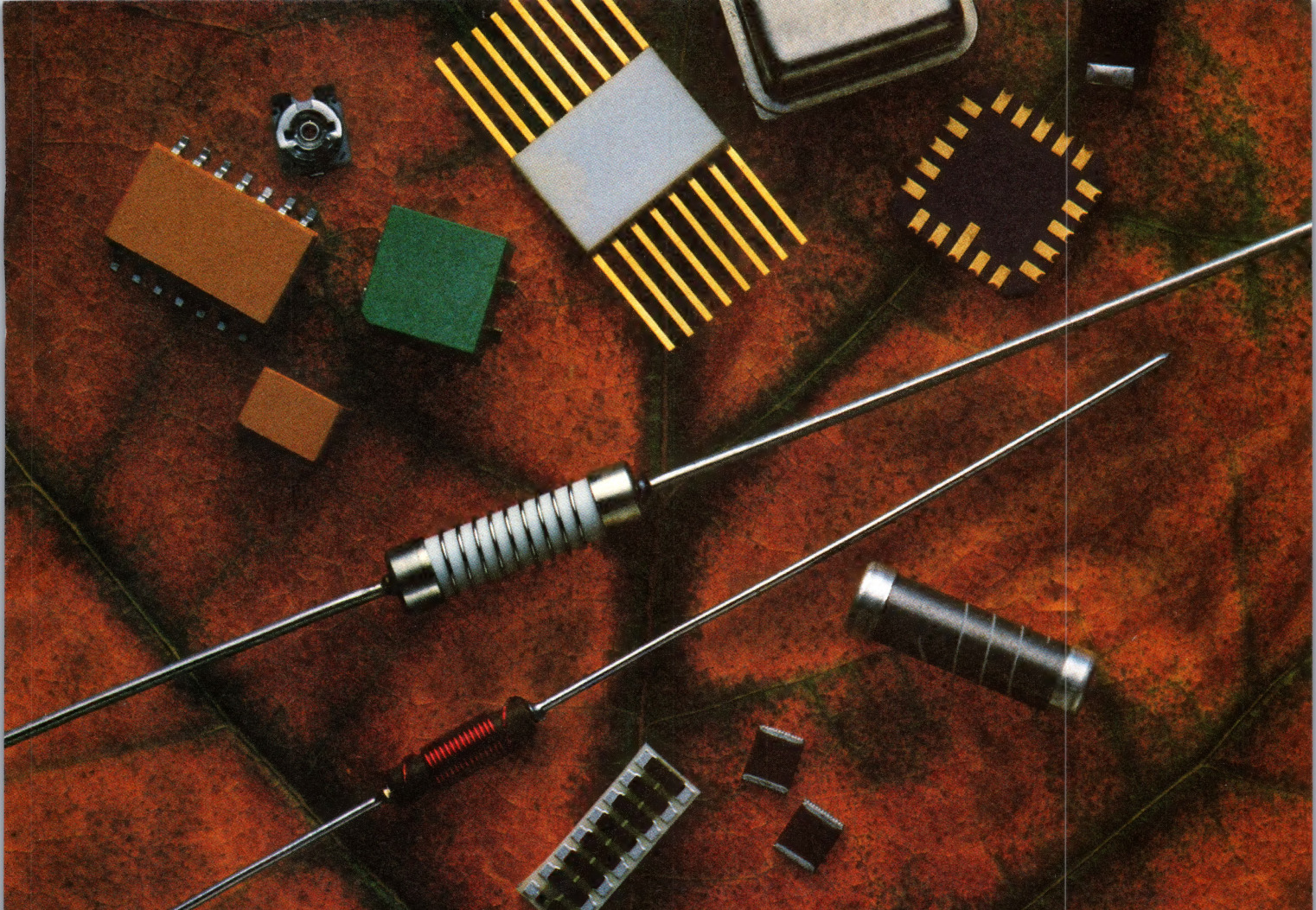
PAL is a trademark of AMD/MMI. ©1988 NAPC

Signetics

Philips Components



PHILIPS



The ultimate in components partnering. Which supplier can deliver all the elements?

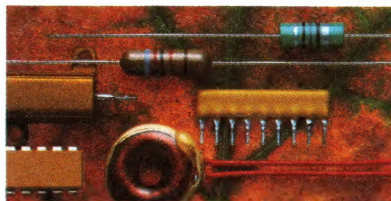
Dale® has been perfecting the elements of partnering for nearly three decades. We began with a commitment to be the absolute best supplier of fixed resistors and associated components. The best at a technology which many said couldn't be improved. But we've done it.

When the industry was ready to surface mount, we were ahead of the game with the largest selection of



Dale Makes Your Basics Better

Dale® Can.



resistive components available. When ship-to-stock came on the scene, our ZIP® program was the first to eliminate the need for receiving inspection while guaranteeing on-time delivery. And, since 1972, our innovative electronic data interchange (EDI) system has grown into an

international network.

Behind this solid supply commitment is a quality structure for which perfection is seen as an attainable goal. It encompasses everything from Certified Suppliers to Quality Circles to fully integrated Statistical Process Control.

Partnering. There's only one components supplier with the experience, size and commitment to make it work to your ultimate advantage. Dale can. Contact your Dale Representative or phone our Corporate Marketing Department at (402) 563-6549.

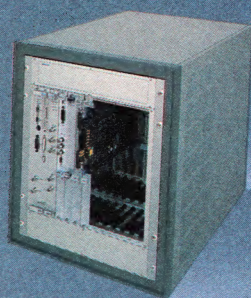
DALE ELECTRONICS, INC.
... a VISHAY Company

DOS + QuickBASIC or C + Instrumentation Code Generation = ?

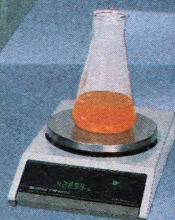
There's only one solution...

LabWindows®

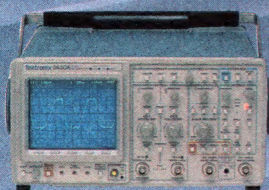
time-saving, easy-to-use program development tools
for instrument control and data acquisition and analysis



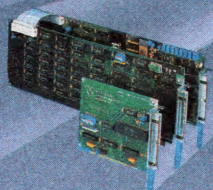
VXI



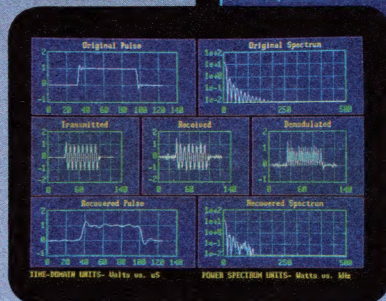
RS-232



GPIB



Plug-in Boards



Are you using a DOS-based personal computer for controlling instrumentation? Do you want the best available software tools for acquiring and analyzing data using standard DOS programming languages? If your answer to these questions is yes, LabWindows is just the solution you're looking for. The unique LabWindows function panel interface lets you interactively control your instrumentation hardware and collect data, as well as automatically generate Microsoft® C or QuickBASIC program code for your application.

With LabWindows you can control GPIB, RS-232, or VXI instruments, or plug-in data acquisition cards for PS/2 and PC-AT computers. For standalone instrument users, the LabWindows instrument library has over 50 ready-to-use instrument drivers so you can program your instrument using intuitive instrument-specific function panels, without knowing the instrument inside-out.

Because acquiring data is only one element of your application, LabWindows has a complete set of QuickBASIC and C compatible libraries for data analysis, presentation, and storage. Manipulate arrays, create a histogram, or use the optional Advanced Analysis Library to perform operations such as Fast Fourier Transforms, digital filtering, and curve

fitting. Give your programs a big performance boost using the specially optimized LabWindows analysis routines for computers with an 80387 numeric coprocessor. For your data presentation and storage needs, use the LabWindows Graphics Library to create multiplot graphs, bar charts, or scatter plots, and use the Data Formatting Library for data logging and file operations.

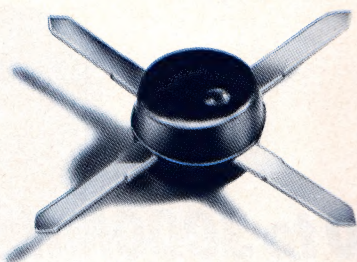
If you're looking for the right tools to take maximum advantage of your DOS computer using QuickBASIC or C for data acquisition and analysis, there is only one solution...LabWindows. Call National Instruments at (800) IEEE-488 to speak with a sales or applications engineer about how LabWindows can help you.

Ask for a FREE Catalog

NATIONAL INSTRUMENTS®
The Software is the Instrument™
12109 Technology Blvd.
Austin, Texas 78727-6204
(512) 794-0100

NATIONAL INSTRUMENTS OF JAPAN (03) 788-1922 •
NATIONAL INSTRUMENTS OF FRANCE (1) 486 53370 •
NATIONAL INSTRUMENTS UNITED KINGDOM (06) 355-23545 •
ARGENTINA (1) 46-5776 • AUSTRALIA (2) 736-2888 • BELGIUM (2) 466-8199 • CANADA
(416) 890-2010, (613) 596-9300, (514) 747-7878, (403) 295-0822, (604) 988-2195 • CHILE (2) 225
3689 • DENMARK (2) 251-122 • FINLAND (0) 372 144 • GREECE (1) 361-1283 • HONG
KONG (2) 0426-2707 • IRELAND (846) 661414, (3) 427-2282 • ISRAEL (3) 324 298 • ITALY
(2) 984-91071-2-3 • KOREA (2) 776-5340 • MEXICO (5) 660-4323 • THE NETHERLANDS (7)
099-6360 • NEW ZEALAND (9) 444-2645 • NORWAY (2) 53-1250 • PORTUGAL (1) 545-313 •
SINGAPORE (65) 336-4713 • SOUTH AFRICA (011) 787-0473 • SPAIN (1) 455-8112 •
SWEDEN (8) 792-1100 • SWITZERLAND (6) 552-8949 • TAIWAN/THE REPUBLIC OF
CHINA (02) 703-6280 • THAILAND (2) 234-9330 • WEST GERMANY (89) 80-7081

from



dc to 2000 MHz amplifier series

SPECIFICATIONS

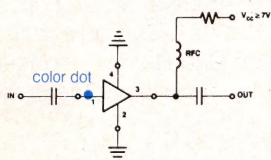
MODEL	FREQ. MHz	GAIN, dB				• MAX. PWR. dBm	NF dB	PRICE \$ Ea.	Qty.
		100 MHz	1000 MHz	2000 MHz	Min. (note)				
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8□	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

NOTE: Minimum gain at highest frequency point and over full temperature range.

- 1dB Gain Compression
- +4dBm 1 to 2 GHz

designers amplifier kit, DAK-2

5 of each model, total 35 amplifiers
only \$59.95



finding new ways ...
setting higher standards

Mini-Circuits

Unbelievable, until now...tiny monolithic wide-band amplifiers for as low as 99 cents. These rugged 0.085 in.diam., plastic-packaged units are 50ohm* input/output impedance, unconditionally stable regardless of load*, and easily cascable. Models in the MAR-series offer up to 33 dB gain, 0 to +11dBm output, noise figure as low as 2.8dB, and up to DC-2000MHz bandwidth.

*MAR-8, Input/Output Impedance is not 50ohms, see data sheet.
Stable for source/load impedance VSWR less than 3:1

Also, for your design convenience, Mini-Circuits offers chip coupling capacitors at 12 cents each.†

Size (mils)	Tolerance	Temperature Characteristic	Value
80 x 50	5%	NPO	10, 22, 47, 68, 100, 220, 470, 680, 1000 pf
80 x 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 x 60	10%	X7R	.022, .047, .068, .1µf

† Minimum Order 50 per Value
• Designers kit, kcap-1.50 pieces of
each capacitor valve, only \$99.95

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

C113-Rev. D

SPDT & SP4T SWITCHES

WITH BUILT-IN DRIVERS



SPECIFICATIONS

	TOSW-230 ZSDR-230		TOSW-425 ZSDR-425	
	10-3000		10-2500	
Freq. Range(MHz)				
Insert. Loss (dB)	typ.	max.	typ.	max.
10-100MHz	1.3	1.9	1.3	1.7
100-1500MHz	1.1	1.9	1.1	1.7
1500-3000MHz	1.8	2.7	1.8	2.5
Isolation(dB)	typ.	min.	typ.	min.
10-100MHz	60	40	60	40
100-1500MHz	40	28	40	30
1500-3000MHz	35	22	35	22
1dB Compression(dBm)	typ.	min.	typ.	min.
10-100MHz	17	6	17	6
100-1500MHz	27	19	27	19
1500-3000MHz	30	28	30	28
VSWR(ON)	typ.	max.	typ.	max.
	1.3	1.6	1.3	1.6
Switching Time (μsec)	typ.	max.	typ.	max.
(from 50% TTL to 90% RF)	2.0	4.0	2.0	4.0
Oper. Temp.(°C)	-55 to +100		-55 to +100	
Stor. Temp.(°C)	-55 to +100		-55 to +100	
Price (10-24)	\$39.95		\$59.95	
(1-9)	\$89.95		\$109.95	

10 to 3000MHz from \$39⁹⁵

Now, high-speed, high-isolation switches with built-in drivers, tough enough to pass stringent MIL-STD-202 tests. There's no longer any need to hassle with the complexities of designing a TTL driver interface and then adding yet another component to your subsystem... it's already included in a rugged, low-cost, compact assembly.

Available in the popular hermetically-sealed TO-8 package or a small EMI-shielded metal connectorized case, these tiny PIN-diode reflective switches, complete with driver, can operate over a 10 to 3000MHz span with a fast 2μsec switching speed.

Despite their small size, these units offer isolation as high as 40dB(typ), insertion loss of only 1.1dB(typ), and a 1dB compression point of +27dBm over most of the frequency range. All models are TTL-compatible and operate from a dc supply voltage of 4.5 to 5.5 V with 1.8mA quiescent current.

Switch to Mini-Circuits for highest quality innovative products... and leave the driving to us.

finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

WE ACCEPT AMERICAN EXPRESS

CIRCLE NO 17

I126 REV.A



On the cover: Ada can make your real-time projects soar—whether they're military or commercial. See the Special Report, beginning on pg 102. (Photo courtesy Telesoft; art direction by Business Art)

SPECIAL REPORT

Real-time Ada

102

The growing use of 32-bit μ Ps, with their 4G-byte address spaces, allows engineers to create embedded systems incorporating truly gargantuan programs. Popular programming languages are hard pressed to support programs forged with megalines of code, but Ada meets that challenge.—*Steven H Leibson, Regional Editor*

DESIGN FEATURES

Troubleshooting analog circuits Part 7

129

Although transistors—both bipolars and MOSFETs—are immune to many problems, you can still have transistor troubles. Robust design methods and proper assumptions regarding their performance characteristics will steer you past the shoals of transistor disasters. After taking on 2-terminal devices in part 6, Bob covers these 3-terminal devices. Future parts will cover analog ICs.—*Robert A Pease, National Semiconductor Corp*

Astute designs improve efficiencies of linear regulators

151

Linear voltage regulators outperform switching-type devices in many applications, but they have one major drawback—poor efficiency. By employing careful design techniques and using new regulator components, you can greatly improve efficiencies.

—*Jim Williams, Linear Technology Corp*

Differential techniques move TDR into the mainstream

171

No longer the esoteric armament of the microwave world, time-domain reflectometry and time-domain transmission now meet a variety of today's troubleshooting needs. Differential and multichannel TDR/TDT give a complete picture of system and component characteristics.—*Jon Lueker, Tektronix Inc*

Continued on page 7

A large, detailed 3D wireframe model of an electronic package is shown. A human hand is visible in the upper left corner, with the index finger pointing towards the model. The model consists of a green rectangular frame with internal structures, including a series of vertical green bars and a central purple component. The background is dark, making the wireframe stand out.

From wireframe to solid with just a touch.

Mentor Graphics lets electronic package designers automatically convert 3D wireframes to solid models.

That's right. The benefits of solid models. Directly from wireframe. Automatically.

Just enter your design using familiar, efficient wireframe techniques. Then automatically convert to solids. With shaded images. Geometric and mass properties. And hidden line removal.

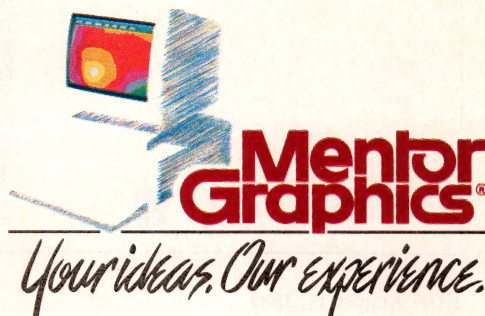
Package Station is the first CAE/CAD system designed expressly for the electronic package engineer. With geometric modeling, drafting, technical documentation and thermal analysis all in a single system. And tight links to Board Station, our PCB layout system.

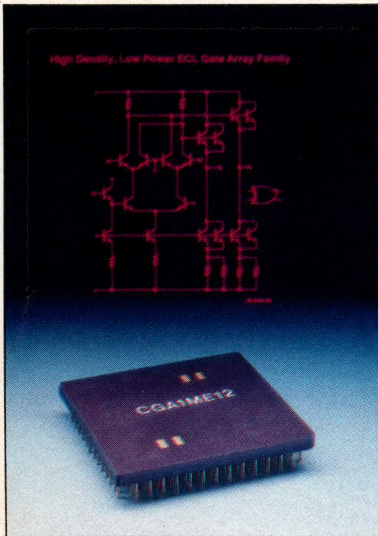
For the first time, PCB and package designers can share vital design information. Immediately. Accurately. And perform thermal analysis that includes conduction, forced convection and radiation.

At last, you head off both mechanical and thermal problems before they ever reach manufacturing.

So let us show you why we've got the right touch in electronic package design.


Phone 1-800-547-7390.





You can choose from a wide variety of ECL gate arrays and PLDs to solve your high-performance system needs (pg 73).

EDN magazine
now offers
Express Request,
a convenient way
to retrieve product
information by
phone. See the
Reader Service
Card in the front
for details on how
to use this free
service.

Express Request 

TECHNOLOGY UPDATES

Military relays: 59 Devices let aircraft use higher voltages

The electronic subsystems for tomorrow's aircraft will derive their power from high-voltage dc power systems. Advanced military relays enable next-generation aircraft to use these higher dc voltages.—*Margery Conner, Regional Editor*

ECL-programmable gate arrays and PLDs: 73 ECL ICs play a role in high-speed computers

The never-ending quest for high performance in workstations, mainframes, ATE, telecommunications, and military systems mandates the use of high-speed, semicustom ASICs. Gate arrays satisfy applications requiring medium- to large-scale complexities, whereas PLDs are ideal for less complex designs. Each technology, however, has its pros and cons.—*John Gallant, Associate Editor*

PRODUCT UPDATE

DC-coupled logarithmic amplifier 96

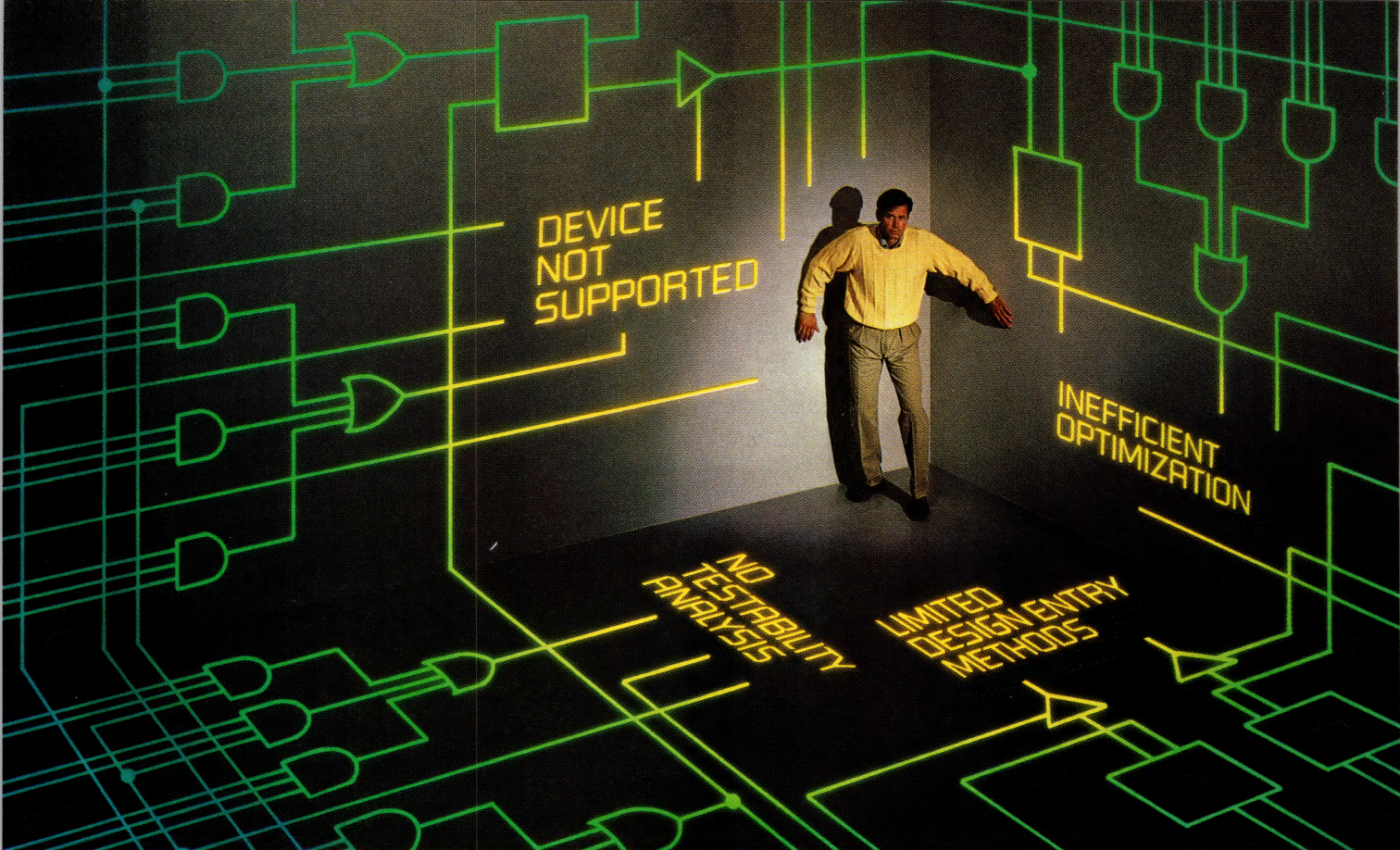
DESIGN IDEAS

Circuit converts pulse height to width 191

DRAM tester yields GO/NO-GO information 193

Continued on page 9

Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business Magazines for Building & Construction ☐ Manufacturing ☐ Foodservice & Lodging ☐ Electronics & Computers ☐ Interior Design ☐ Printing ☐ Publishing ☐ Industrial Research & Technology ☐ Health Care ☐ and Entertainment. Specialized Consumer Magazines: ☐ American Baby ☐ and Modern Bride.



DON'T GET CORNERED BY LIMITED PLD DESIGN SOFTWARE.

A close look at most PLD design software reveals disturbing dead-ends. Unsupported devices, limited design entry methods, inefficient optimization, and lack of testability analysis can stop the design process cold.

Data I/O® gives you powerful PLD design software that outperforms the competition in every category. And we can prove it.

MORE DEVICES SUPPORTED. Data I/O supports more PROMs, traditional PLDs, complex PLDs, and FPGAs. Our device coverage includes every semiconductor manufacturer on the market and more than 200 different device architectures.

MORE DESIGN ENTRY METHODS. Enter your design using any combination of high-level logic equations, truth tables, state machines, or schematics. Only Data I/O offers true high-level design entry.



Data I/O supports more computing platforms including 286- and 386-based PCs, Sun & Apollo workstations, VAXs and Apples.

MORE LEVELS OF VERIFICATION. Behavioral verification checks the circuit's function as you design. After synthesis, partitioning and PLD selection, structural verification provides full debugging of every fuse, node and pin.

MORE EFFICIENT OPTIMIZATION. Produce more compact, efficient designs with multiple levels of reduction —

optimized for each device architecture — and automatic factoring.

FULL TESTABILITY ANALYSIS. Using fault grading techniques, our tools analyze the testability of your circuit and identify untestable portions. They also automatically generate test vectors to provide the best fault coverage possible.

MORE OUTPUT FORMATS. Our tools generate output for PROMs, PLDs, and FPGAs. We can provide pinlists, netlists, Berkeley PLA files, and schematics — whatever output you need for the technology you're using.

MAKE US PROVE IT. Data I/O has the world's most powerful PLD design tools. Call today and make us prove it.

1-800-247-5700
Ext. 387

Data I/O Corporation 10525 Willows Road N.E., P.O. Box 97046, Redmond, WA 98073-9746, U.S.A. (206) 867-6899/Telex 15-2167
Data I/O Canada 6725 Airport Road, Suite 302, Mississauga, Ontario L4V 1V2 (416) 678-0761
Data I/O Europe World Trade Center, Strawinskylaan 633, 1077 XX Amsterdam, The Netherlands +31 (0)20-6622866/Telex 16616 DATIO NL
Data I/O Japan Sumitomoseimei Higashishinbashi Bldg., 8F, 2-1-7, Higashi-Shinbashi, Minato-Ku, Tokyo 105, Japan
(03) 432-6991/Telex 2522685 DATAIO J

VP/Publisher
Peter D Coley

VP/Editor/Editorial Director
Jonathan Titus

Managing Editor
John S Haystead

Assistant Managing Editor
Joan Morrow

Special Projects
Gary Legg

Home Office Editorial Staff
275 Washington St, Newton, MA 02158
(617) 964-3030

Tom Ormond, *Senior Editor*

Jay Fraser, *Associate Editor*

John A Gallant, *Associate Editor*

Michael C Markowitz, *Associate Editor*

Dave Pryce, *Associate Editor*

James P Scanlan, *Associate Editor*

Julie Anne Schofield, *Associate Editor*

Charles Small, *Associate Editor*

Dan Strassberg, *Associate Editor*

Anne Watson Swager, *Associate Editor*

Chris Terry, *Associate Editor*

Kathleen M Vejvoda, *Associate Editor*

Helen McElwee, *Senior Copy Editor*

Susan L Infantine, *Senior Production Editor*

Christine McElvenny, *Production Editor*

Brian Tobey, *Production Editor*

Editorial Field Offices

Steven H Leibson, *Senior Regional Editor*
Boulder, CO: (303) 494-2233

Margery S Conner, *Regional Editor*
Atascadero, CA: (805) 461-9549

Doug Conner, *Regional Editor*
Atascadero, CA: (805) 461-9669

J D Mosley, *Regional Editor*
Arlington, TX: (817) 465-4961

Richard A Quinnell, *Regional Editor*
San Jose, CA: (408) 296-0868

Maury Wright, *Regional Editor*
San Diego, CA: (619) 748-6785

Contributing Editors

Robert Pease, Bob Peterson,
Don Powers, Bill Travis

Editorial Services

Kathy Leonard, *Editorial Coordinator*
Nancy Weiland, Helen Benedict

Art Staff

Ken Racicot, *Senior Art Director*

Chinsoo Chung, *Associate Art Director*

Cathy Filipski, *Staff Artist*

Martha Crowell, *Staff Artist*

Production/Manufacturing Staff

Andrew A Jantz, *Production Supervisor*

Danielle M Biviano, *Production Manager*

Deborah Hodin, *Production Assistant*

Sandy Wucinich, *Production Assistant*

Diane Malone, *Composition*

Director of Art Department

Joan Kelly

Norman Graf, *Associate*

VP/Production/Manufacturing

Wayne Hulitzky

Director of Production/Manufacturing

John R Sanders

Business Director

Deborah Virtue

Marketing Communications

Anne Foley, *Promotion Manager*

Sara Morris, *Marketing Services Administrator*

Gordon Keegan, *Promotion Specialist*

EDITORIAL

49

The electronics industry should learn from the FSX debates:
Don't force your partners to become competitors.

NEW PRODUCTS

Computers & Peripherals	205
Components & Power Supplies	214
Integrated Circuits	222
CAE & Software Development Tools	230
Test & Measurement Instruments	241

DEPARTMENTS

News Breaks	21
Signals & Noise	33
Calendar	42
Literature	250
Business/Corporate Staff	261
Career Opportunities	262
EDN's International Advertisers Index	274



You don't need us to tell you that all SRAMs are in short supply.

SRAMS WITH AN INTERESTING NEW FEATURE.

We have met the challenge by investing in increased SRAM production facilities.

The result? Fast and slow SRAMs **AVAILABILITY.** manufactured to the highest standards, competitively priced and readily available in quantity — now.

INMOS already supply 14% of the fast SRAMs used in the US and 30% of the European requirement — so we understand the needs of sophisticated SRAM users including, of course, the military.

Our extensive range covers everything from 4k to 64k, including the all-important 8k×8 — all available in a variety of packages, “off the shelf”. The Inmos 256k SRAM is about to be added to the range.

If you need SRAMs and you need them now, there's never been a better time to talk to us.

Organisation	Part No.	Access Time	Organisation	Part No.	Access Time
4K×1	IMS 1203	20,25,35,45	2K×8	MK6116L	150,200
	IMS 1203M	25,35,45		MK16116	150,200
1K×4	IMS 1223	20,25,35,45		MK16116L	150,200
	IMS 1223M	25,35,45	64K×1	IMS 1600	20,30,35,45,55
16K×1	IMS 1403	25,35,45,55		IMS 1601L	45,55
	IMS 1403M	35,45,55		IMS 1600M	45,55,70
	IMS 1403LM	35,45,55		IMS1601LM	45,55,70
	IMS 1400M	45,55,70	16K×4	IMS 1620	25,30,35,45,55
	MK41H67	20,25,35		IMS 1620M	45,55,70
4K×4	IMS 1423	25,35,45,55		IMS 1620LM	45,55,70
	IMS 1423M	35,45,55		IMS 1624	25,30,35,45,55
	IMS 1420M	55,70	8K×8	IMS 1624M	45,55,70
	MK41H68	20,25,35		IMS 1624LM	45,55,70
	MK41H69	20,25,35		IMS 1630M	55,70
	MK41H79	25,35		IMS 1630L	45,55,70,100,120
2K×8	MK6116	150,200		MK48H64	70,120
				MK48H64L	70,120

Key: M — Mil-std-883C, L — Low Power. Available soon — a new 256K SRAM.

For a copy of our 1989 Databooks or, of course, a quote, contact your local INMOS or SGS-THOMSON Microelectronics office.



INMOS is a member of the SGS-THOMSON Microelectronics Group



INMOS Limited, Aztec West, Bristol BS12 4SQ, UK. Tel: (0454) 616616. Colorado, USA. Tel: (719) 630 4000 · Munich, Germany. Tel: (089) 319 10 28 · Paris, France. Tel: (1) 46 87 22 01 · Tokyo, Japan. Tel: (03) 505 2840

If you're not first



you're finished.

Getting to market fast is as important as getting data from memory. If there's a delay, you're not just late. You're sunk.

Help from high performance EPROMs.

AMD has ways to increase your speeds at both ends. Our high performance CMOS EPROMs. From 64K to 1Mb with killer speeds to match today's high performance microprocessors.

But the best thing is that they're all on the shelf right now. So you can get your project to market that much sooner.

We also have ExpressROM™ devices, the fastest alternative to traditional mask-programmed ROMs. You get your ROMs in weeks instead of months.

So after you've looked at performance and densities, ask yourself who can get you to market first.

It's probably the fastest decision you'll make all day.



Advanced Micro Devices

For more information write "high performance memories" on your letterhead and mail to:
(In Europe) AMD Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS United Kingdom.
(In Asia) Advanced Micro Devices Far East Ltd., Rm. 1201-2 Harcourt House, 39 Gloucester Road, Hong Kong. Attn: Andrew Ng.
(In Japan) Advanced Micro Devices Japan Ltd., Shinjuku Kokusai Bldg. 6-6-2 Nishi-Shinjuku, Shinjuku-ku, Tokyo 160, Japan.

Bruxelles (02-2) 771 91 42 • Geneva (02) 2880025 • Hannover area (0511) 73 60 85 • Hong Kong (5) 8654525
London area (0483) 740440 • Manchester area (0925) 828008 • Milano (02) 3533241 • München (089) 41 14-0
Osaka (06) 243-3250 • Paris (1) 49 75 10 10 • Seoul (02) 784-7598 • Singapore (65) 348 1188 • Stockholm (08) 733 03 50
Stuttgart (0711) 62 33 77 • Taiwan (02) 7213393 • Tokyo (03) 345-8241

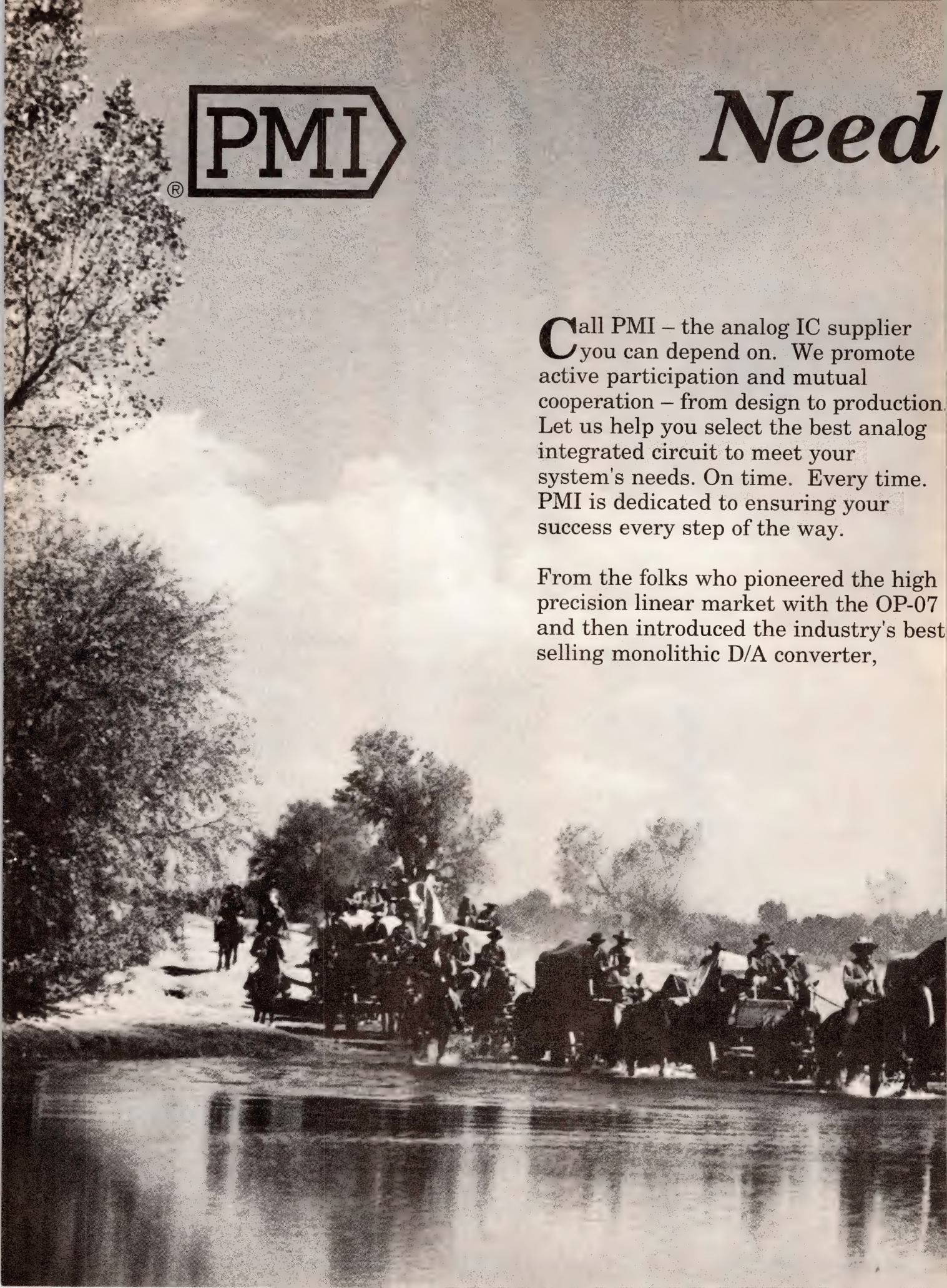
Latin America: Fort Lauderdale, Florida/U.S.A. Tel: (305) 484-8600 Tlx: (510) 955-4261 amd ftl
© 1989 Advanced Micro Devices, Inc. ExpressROM is a trademark of Advanced Micro Devices, Inc.



Need

Call PMI – the analog IC supplier you can depend on. We promote active participation and mutual cooperation – from design to production. Let us help you select the best analog integrated circuit to meet your system's needs. On time. Every time. PMI is dedicated to ensuring your success every step of the way.

From the folks who pioneered the high precision linear market with the OP-07 and then introduced the industry's best selling monolithic D/A converter,



A Leader On The Analog Frontier?

the DAC-08, you can expect continued technological leadership. Even today, our leading edge continues with the OP-177, the highest precision operational amplifier on the market, and our extensive line of dual and quad D/A converters. And PMI's twenty years of experience prove the power of partnership as well. New on the frontier are PMI's SPICE models, the first to accurately model high-speed op amps... demonstrated commitment to your successful design. The depth and breadth of PMI's product line includes audio, communications, medical imaging, standard industrial, and satellite applications. As a proven leader in the military market,

we offer high reliability ICs including MIL-M-38510 Level B and JAN Class "S" qualified products. Our extended industrial temperature range and broad line of SMD package devices show our commitment to high performance ICs that meet your needs.

If you need competitive pricing, high reliability and performance, wide selection, and committed applications assistance, choose a leader you can depend on. PMI.

Precision Monolithics Inc.
1500 Space Park Drive
Santa Clara, CA 95054-3434
800-843-1515



The New Harris Semiconductor.

Wherever there's no second chance, we're number one.



Whenever there's no second chance for your circuit designs, you need the reliability and experience of the semiconductor leader in military and aerospace. The New Harris Semiconductor.



Our recent integration of three semiconductor leaders—Harris, RCA, and GE—focuses even greater resources on our long-standing expertise in harsh environments. We have a complete division

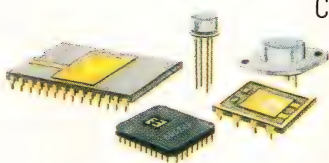


dedicated to military and aerospace semiconductor design and development—giving you the assurance of program management, parts control, design, documentation and manufacturing optimized for

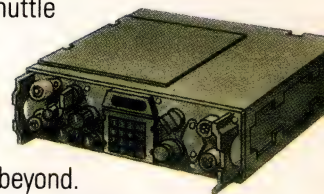
your unique needs.



We serve your needs by meeting virtually every military standard. Our MIL Certifications M38510, BS9000, and S19500, both Class B and Class S facilities and products, and QML beta site status help you meet reliability requirements on your total bill of materials. And give you the confidence of a partner whose experience extends from the space shuttle



Columbia to the space station Columbus, from Voyager to Magellan, from the F-16 to ATA/ATF, from AMRAAM to SADARM and far beyond.

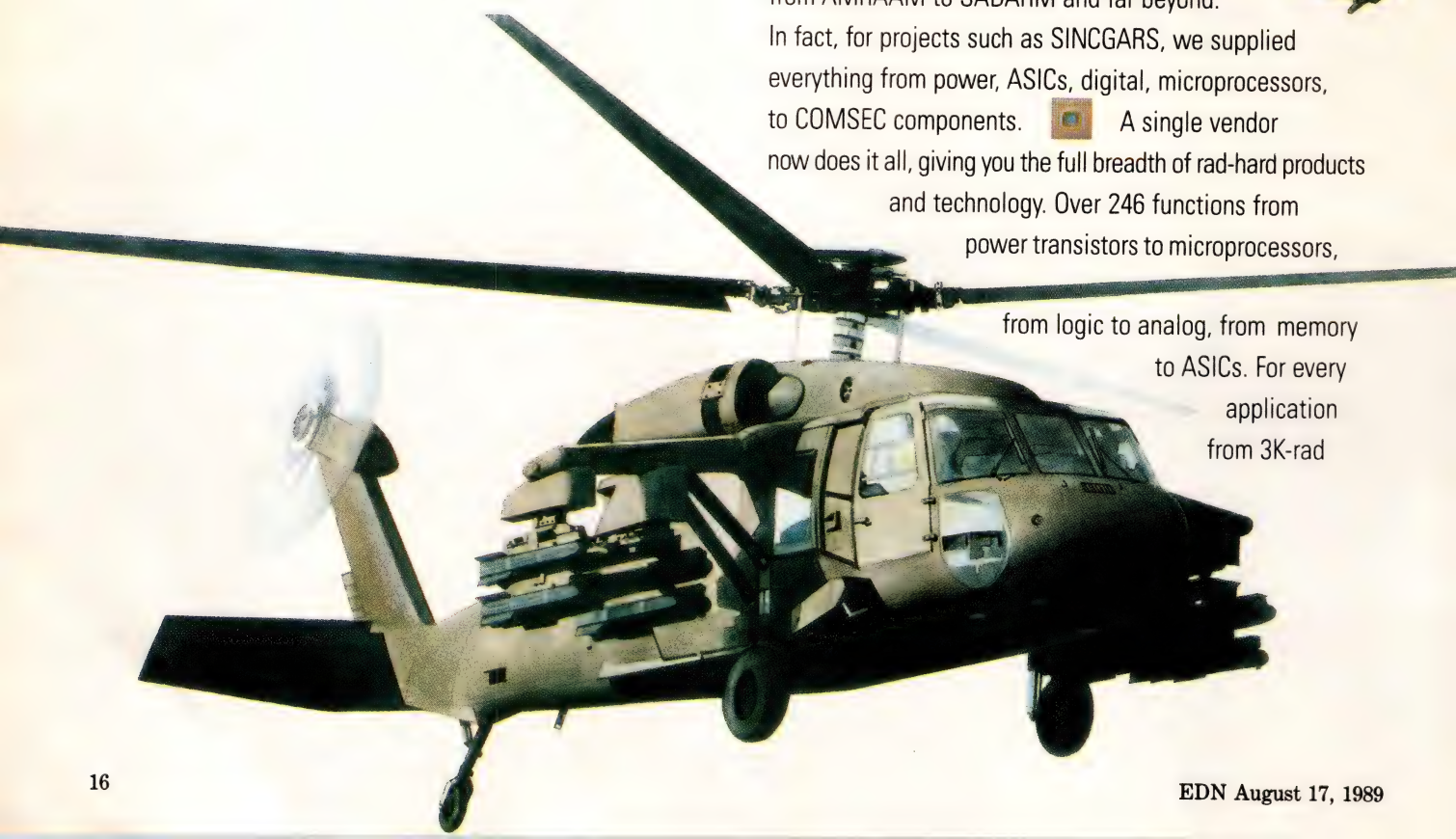


In fact, for projects such as SINGARS, we supplied everything from power, ASICs, digital, microprocessors, to COMSEC components.




A single vendor now does it all, giving you the full breadth of rad-hard products and technology. Over 246 functions from power transistors to microprocessors,

from logic to analog, from memory to ASICs. For every application from 3K-rad





tactical to mega-rad space and strategic systems. 


Harris has built its reputation on custom circuits, with rad-hard capabilities designed in. No wonder we offer some of the most complete custom and semicustom capabilities in the industry—including analog, digital, and smart power.

We offer a full complement of design tools and simulators for all phases of the design process. Our rad-hard and mil temp libraries speed your time to market. And our worldwide design centers work with you to ensure


ASICs that work first time,

on time.  Moreover,

our custom, semicustom and standard products offer a range of technologies unequalled in the industry—DI bipolar, CMOS, SOS/SOI, biCMOS and GaAs.

 As inventors of CMOS, we offer a full line of low-power, high-noise immunity products ideal for signal processing and control. And a full line of logic devices from the CD4000 to the 54HC and 54AC with


advanced CMOS logic for replacing power-hungry TTL.

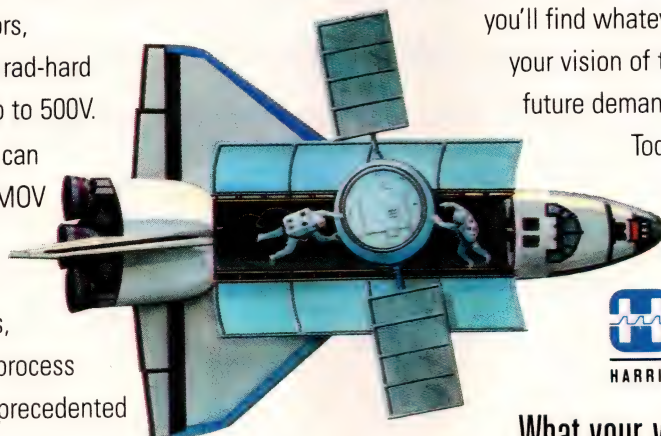
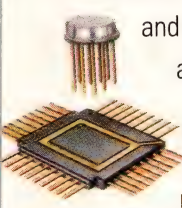
 We give you the power to control your designs, too. Including over 60 QPL MOSFETs,

and bipolar transistors,

and N/P channel rad-hard MOSFETs at up to 500V.

And we also can provide over 50 MOV SMD/DESC drawings.

 And for "real world" analog problems, our dielectric isolation process offers products with unprecedented

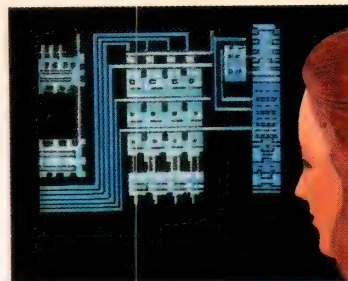


performance; such as high-speed op amps with slew rates to 1000 V/ μ sec, and multiplexers with active overvoltage protection. We have high-speed analog


switches and precision/low-power amplifiers, too—all designed for and guaranteed to military specifications.

And in GaAs, we provide both 0.5 micron and 1 micron processes with 0.25 micron in development. Plus we're MIMIC program participants, offering both custom and standard products through our domestic turnkey in-house manufacturing.


 Moreover, we're expanding our facilities at Melbourne, Florida to continue our commitment to world-class,



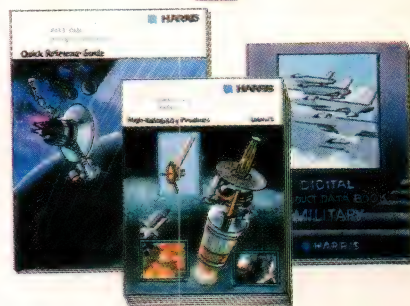
mil spec IC production. Our ongoing SPC and TQC programs provide

you with levels of reliability unavailable just a few years ago. And our RHAP™ (Rad-Hard Assurance Program) gives you guaranteed rad-hard standard products for tactical applications. 

So wherever there's no second chance, look to number one. The New Harris Semiconductor. 

Write or call 1-800-4-HARRIS today for our free quick reference guide to all our military and aerospace capabilities. Or our digital and analog military data books.  At the New Harris Semiconductor,

you'll find whatever your vision of the future demands. Today.

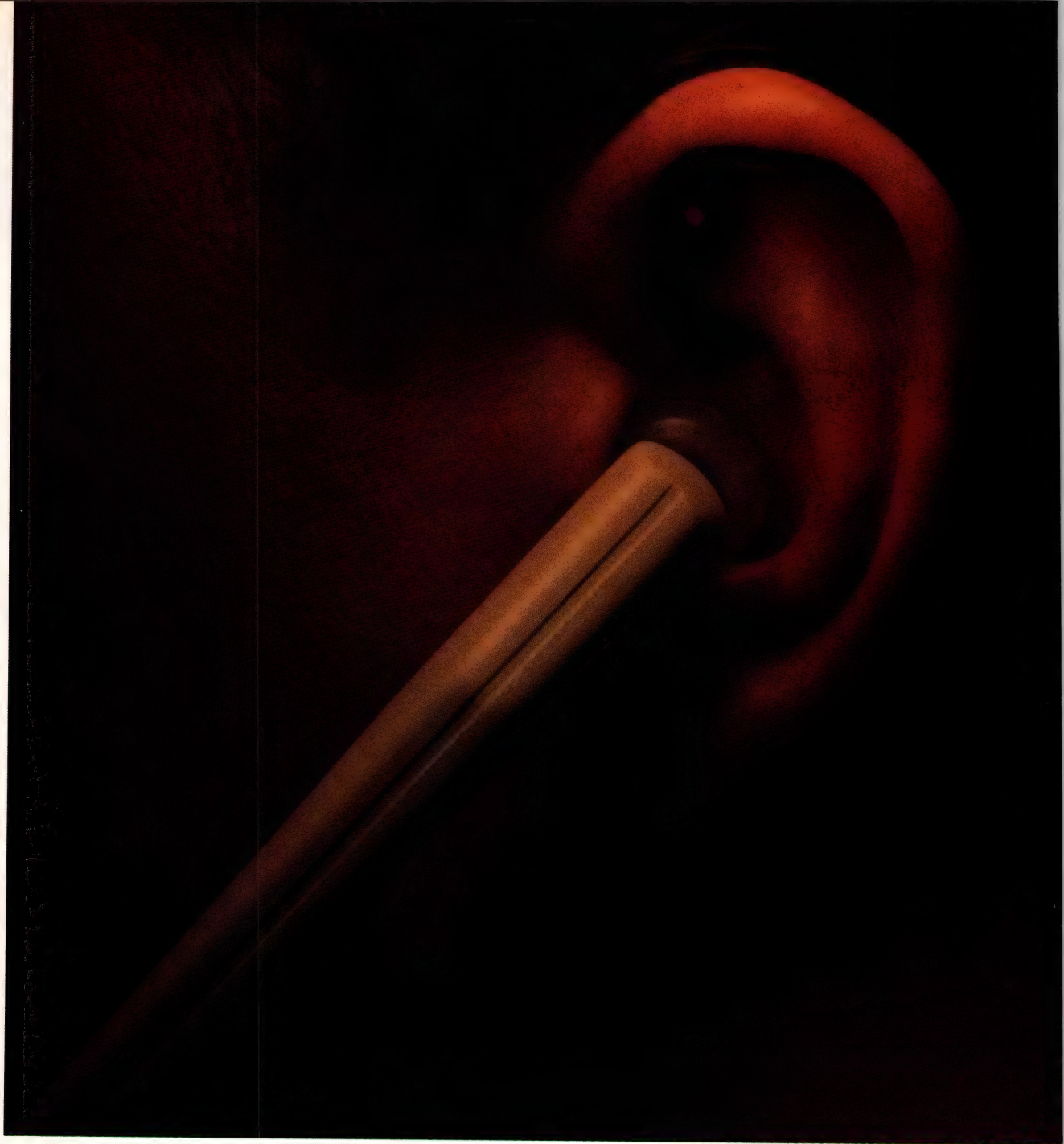


 **HARRIS**
SEMICONDUCTOR
HARRIS • RCA • GE • INTERSIL

What your vision of the future demands. Today.

RHAP is a trademark of Harris Corporation

CIRCLE NO 32



Even though we're one of the world's
largest sources for electronic components, you'll
still find us in some pretty small places.

ITT ElectroMechanical Components Worldwide. Our name not only describes what we do, but it also says we're an international company, with worldwide presence. So, it should really come as no surprise that you'll find our products in everything from the rotary dial in a telephone headset, to places like Willow Springs.

Fact is, you can find our switches, relays, connectors, cable assemblies and test accessories in virtually every part of the world. In almost every application.

Whether it's in telecommu-

nications, instrumentation, medical electronics, automotive, military, aerospace, computers or consumer electronics, ITT EMC Worldwide has the experience and technical expertise to help you build a quality product, every time.

For seventy-five years, our engineering strength and customer support have been second to none. That's why many of the world's leading companies select us for their ship-to-stock programs.

When you do business with the companies of ITT EMC Worldwide,

you can always expect quality, service and on-time delivery. And no matter where you are in the world, chances are we've got a representative nearby.

So, drop us a line today. And see how small a one billion dollar company can be.

*1851 East Deere Avenue
Post Office Box 35000
Santa Ana, CA 92705-6500
Or call (714) 261-5300*

ITT ElectroMechanical
Components Worldwide
Discover our strengths.

SIEMENS



A19100-PR100-x-7600

Less is more

**with our new high-performance
Al electrolytic capacitors
for power electronics**

You really must get to know Siemens B 43550 / B 43570 electrolytic series. If only to appreciate how they compare to run-of-the-mill capacitors in performance. They produce more of it from less capacitor, saving you space, weight and money.

Their ratings speak for themselves:

rated voltage up to 400V, current handling up to 50 A, good heat dissipation through metallic contact between winding and case bottom (projecting cathode foil), lifetime in terms of decades and working temperatures up to 105°C.

All in all, capacitors with an attractive budget.

Less	More
⊖ space	current handling ⊕
⊖ weight	temperature ⊕
⊖ cost	useful life ⊕

And because our range of Al electrolytic capacitors is so diversified, we can always come up with the optimal solution. You can call us for advice at any time, for application-specific designs too. For an initial briefing write

Siemens AG,
Division Passive Components and
Electron Tubes, PRVF,
Balanstrasse 73,
D-8000 Munich 80
quoting
"High-performance electrolytic caps."

**The components make it -
Siemens.**

NEWS BREAKS

EDITED BY JULIE ANNE SCHOFIELD

INSTRUMENT-COMMAND SYNTAX TARGETS UNIVERSAL APPLICATION

Hewlett-Packard Co (Loveland, CO, (800) 752-0900) has announced that it will license an extensible instrument-command syntax called TMSL (test and measurement systems language). All of the company's VXIbus products and all rack-and-stack instruments it develops from now on will support TMSL. With the syntax, you issue the same command to obtain a measurement of, say, frequency, whether the instrument making the measurement is a counter/timer, a scope, or a spectrum analyzer and regardless of whether the instrument is a rack-and-stack unit or a VXI module. Thus, your instrument-control program is independent of the system hardware.

TMSL commands work in programs written in many high-level languages, including Basic, C, and Pascal. HP's Interactive Test Generator software generates commands in TMSL syntax when creating programs to control instruments that support TMSL. You can transmit TMSL commands over the IEEE-488 bus and over LANs. The book *TMSL syntactic and semantic requirements* and a license to use TMSL in your own designs and extend it without HP's prior approval cost \$100.—Dan Strassberg

DIGITAL POTENTIOMETER CHIP PERMITS REMOTE ADJUSTMENTS

Now you can adjust equipment settings in the field without even opening the enclosure by using a software-controllable, solid-state dual potentiometer introduced by Dallas Semiconductor (Dallas, TX, (214) 450-0400). The DS1267 is a low-power CMOS chip containing two 256-position potentiometers that you can stack for double precision. You change the resistance with digital signals, and you can control an unlimited number of daisy-chained potentiometers with three signal wires. Because the DS1267 contains no mechanical contacts, it induces no operational noise and has an unlimited life. Its digital operation lets you change settings without incrementation and monitor its settings via an on-chip register. The chip can withstand high surface-mount assembly temperatures and sells for \$4.60 (100).—J D Mosley

TACTICAL RAD-HARD ICs OFFERED AT LOW PRICE PREMIUM

United Technologies Microelectronics Center (Colorado Springs, CO, (719) 594-8000) now offers many of its gate arrays and standard military ICs with guaranteed tactical radiation-hardness specs meeting MIL-M-38510 level M (3×10^5 rads (Si)) or level D (1×10^4 rads (Si)) for a price premium ranging from 5 to 10% over the cost of the equivalent, nonradiation-hard part. The company employs epitaxial wafers and silicon-gate CMOS structures to provide immunity to single-event upsets, transient upsets, and latch-up. Thus, the radiation hardness is built, not tested, into the company's tactically radiation-hard parts. UTMC fabricates these ICs using the same process controls it employs on its strategic radiation-hard IC manufacturing line. Low-temperature processing enhances the ICs' total-dose radiation immunity.

In the past, designers of military systems with tactical radiation-hard requirements, such as avionics, shipboard electronics, and ground-based communications systems, had only two choices. They either proved the radiation hardness of nonradiation-hard ICs by testing individual parts, or they overdesigned systems by using parts with strategic radiation-hard specs (1×10^6 rads (Si)). However, these design practices are prohibitively expensive. UTMC's pricing policy for tactically radiation-hard ICs is a third, less costly alternative.—Steven H Leibson

NEWS BREAKS

MULTIPROCESSOR DSP BOARD OFFERS 50-MIPS PERFORMANCE

The VE-32C-01V, 4-processor, VMEbus DSP board targets computationally intensive applications, such as image processing and graphics. Valley Enterprises Inc (Tamaqua, PA, (717) 668-3737) offers the board, which is based on AT&T Technology Systems' (Allentown, PA, (800) 372-2447) DSP32C processor. The board achieves peak performance specs of 50 MIPS and 100M flops. The DSP32C DSP μ P includes 1536 32-bit words of on-chip RAM; the board includes an additional 32k to 128k bytes of static RAM per processor. Software support for the board includes an assembler, a linker, a simulator, and a compiler. The board also comes with a C language applications library that includes math, matrix-manipulation, signal-processing, image-processing, and graphics routines. The VE-32C-01V costs \$7650 (10) with 32k bytes of RAM per processor.—Maury Wright

START-UP INTRODUCES LOW-COST FAULT SIMULATOR

Starting at \$4500, the FasFault family of fault-simulation tools from Intrinsix Corp (Westboro, MA, (508) 836-4100) consists of C-based software programs and an IBM PC/AT-compatible plug-in board. Software that permits the use of the system as a network resource on other Unix workstations costs \$3000. The lowest-cost version of the fault simulator evaluates designs with as many as 10,000 gates; a 25,000-gate version has a \$3000 premium, and a 100,000-gate fault simulator will be available later this year. Intrinsix is committed to offering interfaces between FasFault and many popular software simulators; however, the Viewlogic Workview interface (\$1500) is the only one now available.—Michael C Markowitz

FILE SERVER STORES 3 TERABYTES ON VHS CASSETTES

Honeywell's Test Instrument Div (Denver, CO, (303) 773-4581) fused its videotape-based VLDS data-storage peripheral and a tape-handling robot designed for broadcast-television studios to create the VLA 600, a network file server that connects to Ethernet LANs and stores more than 3T bytes (3 million megabytes) of data. The previously introduced VLDS tape drive stores 5.3G bytes on a VHS videocassette, and the VLA 600 accepts as many as five VLDS drives. When mounted in the tape-handling robot, the tape drive gains access to as many as 600 VHS cassettes, thus resulting in a capacity exceeding that of 18,000 reels of standard 6250-bpi, 9-track tape. Yet the VLA 600—which houses the VLDS drives, the tape-handling robot, and the videotape carousels—measures only 71 × 40 × 78 in. The unit's tape-handling robot can retrieve any cassette in 8 seconds or less. A VME chassis buried in the VLA 600 holds the electronics needed to operate the VLDS tape drives, control the robot, and manage LAN communications using the TCP/IP network-communications protocol. A VLA 600 with two VLDS drives costs \$524,900.—Steven H Leibson

VMEBUS I/O CONTROLLERS TARGET SUN-COMPATIBLE MARKET

Interphase Corp (Dallas, TX, (214) 350-9000) offers five new VMEbus-based I/O controllers, including SCSI, IPI (Intelligent Peripheral Interface), and ESDI models. The boards can be used in any VMEbus applications, but are specifically designed for Sun Microsystems' (Mountain View, CA, (415) 960-1300) workstations. Models V/IPI 4460 (IPI-2 disk controller), V/ESDI 4401 (an ESDI controller with SCSI port), and V/SCSI 4410 (a single- or dual-channel SCSI adapter) all fit the 9U Sun-compatible VMEbus form factor. The boards cost \$4850, \$4195, and \$3595, respectively. The \$1295 V/Sun SCSI 3205 is a 6U direct replacement for Sun's SCSI-2 board. All of the controllers will be available this fall.—Maury Wright



15ns
16K PROM

CY7C245A

25ns
256K SRAM

CY7C199

15ns
22V10 PLD

22V10

3ns
ECL 4K SRAM

CY100E474

25ns
16Kx32 SRAM
Module

CYM1821

CY7C429

30 MHz
2Kx9 FIFO

CY7C601

24 MIPS
32-Bit RISC

Our 1989 data book sets new marks for high performance.

So call for a copy.

Arm yourself with the industry's outstanding selection of very fast, very cool circuits.

RISC. SRAM. PROM. PLD. Logic. SRAM Modules. ECL.

Seven families of circuits that can speed up your current designs.

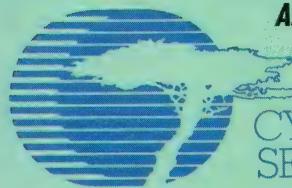
Or give you significant new performance options for your next design.

If you are designing for performance, we have the speed you need.

Data Book
Hotline:

1-800-952-6300*

Ask for dept.
C4B.



CYPRESS
SEMICONDUCTOR



*1-800-387-7599 In Canada. (32)2-672-2220 In Europe. ©1989 Cypress Semiconductor, 3901 North First Street, San Jose, CA 95134 Phone: (408)943-2600, Telex 821032 CYPRESS SNJUD, TWX 910-997-0753.

NEWS BREAKS

INTERFACE SCSI INSTRUMENTS TO YOUR SUN WORKSTATION

The SCSI488/S controller from IOtech Inc (Cleveland, OH, (216) 439-4091) lets you use the SCSI port on your Sun Microsystems (Mountain View, CA, (415) 960-1300) workstation to control IEEE-488 instruments and laboratory peripherals. The \$1495 SCSI488/S doesn't occupy any of your workstation's slots, and any workstation connected via the Sun LAN can access IEEE-488 instruments connected to other workstations at any node on the network. The SCSI488/S comes with driver software for true multitasking, error-correction, and exception handling. You can write programs in any high-level language that controls Unix system services. For \$2495 you can purchase the Sun version of DADiSP, a companion software package for waveform analysis and graphics.—J D Mosley

HALF-HEIGHT, 5¼-IN. HARD-DISK DRIVE STORES 500M BYTES

You can cram 500M bytes of data on the half-height Wren VI from Imprimis Technology Inc (Minneapolis, MN, (612) 936-6271). The \$1560 (OEM qty) drive has an unformatted capacity of 502M bytes, incorporates an embedded-SCSI interface, and features a 16-msec average seek time. This new version of the Wren VI employs the company's patented zone-bit recording method to improve upon its predecessor, the 383M-byte Wren VI, which remains in production.—Steven H Leibson

ANALOG INTERFACE CHIP SIMPLIFIES SPEECH PROCESSING

If you need to improve the quality of speech produced by your cellular phone, wide-band audio, or speech-recognition circuit, investigate the TLC32044 analog-interface chip from Texas Instruments (Dallas, TX, (800) 232-3200). The TLC32044 provides a nominal bandwidth of 100 to 3800 Hz and incorporates a new receive-section filter with independently programmable roll-off points. The chip's transmit and receive filters' ripple is $\pm 1/4$ dB; their measured delays are 250 and 300 μ sec, respectively. The TLC32044 can perform onboard $(\sin x)/x$ frequency-response correction. Pricing begins at \$19.45 (1000).—J D Mosley

PC/XT-COMPATIBLE LAN STATION SUITS EMBEDDED APPLICATIONS

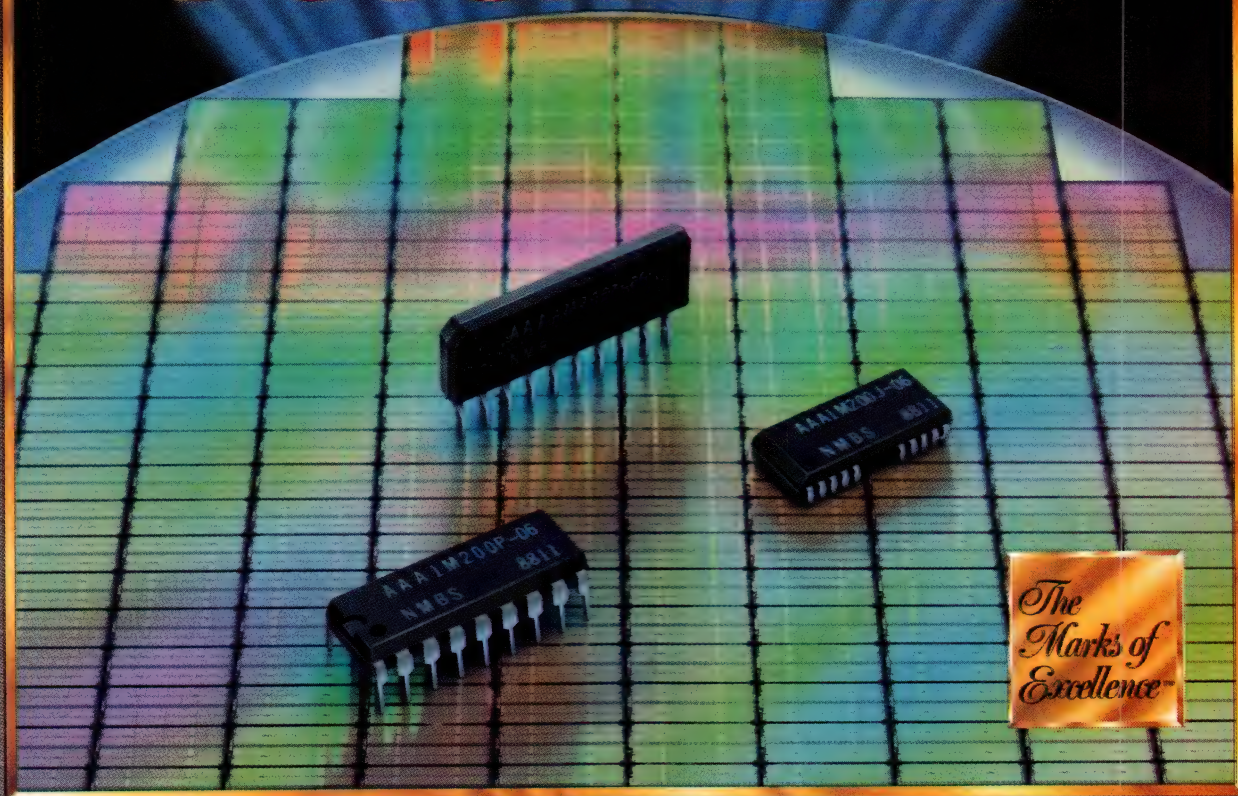
The ST/16 IBM PC/XT-compatible computer module from PC-Office (San Diego, CA, (619) 268-3235) is based on the company's PC-Office LAN. The LAN station includes 768k bytes of RAM, a keyboard interface, a light-pen interface, and a power supply, yet its dimensions are only $4.7 \times 1.8 \times 6.4$ in. The module incorporates the Intel (Santa Clara, CA, (408) 987-8080) 2×4 -in. Wildcard-88 CPU board, which operates at 10 MHz. A half-length IBM PC/XT-compatible add-in slot lets OEMs configure the module for embedded applications, such as factory automation and point-of-sale terminals. The diskless station includes an interface to the PC-Office LAN and can boot from a remote Netbios node. The PC-Office LAN operates using a CSMA/CD communications protocol and can support data transfers as fast as 4M bps. OEM prices for the ST/16 range from \$195 to \$495.—Maury Wright

SCSI IC SUITS PC HOST-ADAPTER AND MOTHER-BOARD USES

The TMC-950 SCSI chip from Future Domain (Tustin, CA, (714) 259-0400) targets SCSI applications in personal computers. The IC includes the glue logic to interface with IBM-compatible PCs and essentially provide a single-chip SCSI implementation. You can use the IC directly on the mother board or on a host-bus-adapter board. The IC supports asynchronous SCSI data transfers as fast as 1.5M bytes/sec; in host-adapter applications, it can sustain transfers across the PC/AT bus at 9.6M bps. The TMC-950 costs \$30.—Maury Wright

NOW FROM NMB TECHNOLOGIES

FUTUREFAST™



60 ns – 1 Mb DRAMS!

They're here! The world's fastest 1Mbit DRAMs. From the same people who brought you the world's first 60ns 256K DRAMs. And is delivering them in ever increasing quantities.

That's leadership. And our new 200 series FutureFast™ 1Mb DRAMs put us even farther out front. They're far faster than anything else on the market. Max access times are 60/70/80ns in both 1M x 1 and 256K x 4 architecture. Imagine cycle times down to 100ns.

Just think. Now you can design true high speed, zero wait-state systems

without complex, costly cache memory or interleaving schemes. And you know you can count on NMB quality and performance.

Available in all popular package styles — plastic and ceramic DIP, ZIP, SOJ and SIMM. All with standard JEDEC pinout. Evaluation samples and volume production available now!

If your advanced microprocessor-based designs demand high speed and high performance, don't be left behind. Call or write us today for complete specs and application data.

Product Line Summary		
Series*	Access Time (ns)	Organization
AAA1M200	60/70/80	256K x 4 / 1Mb x 1
AAA2800	60/70/80	256K x 1

*All series available in static column and page mode. SIMMS and SIPS available for each series.

NMB**NMB TECHNOLOGIES
INCORPORATED**

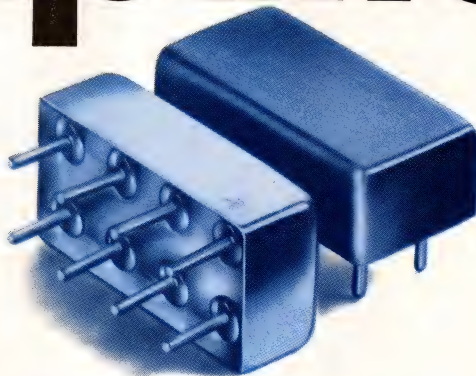
Semiconductor Division

9730 Independence Avenue • Chatsworth, CA 91311

Telephone: (818) 341-3355 • FAX: (818) 341-8207 • TLX: 651340

CIRCLE NO 24

rugged plug-in amplifiers



0.5 to 1000 MHz from \$13⁹⁵ (10 to 24 qty)

Tough enough to meet full MIL-specs, capable of operating over a wide -55° to $+100^{\circ}\text{C}$ temperature range, in a rugged package... that's Mini-Circuits' new MAN-amplifier series.

The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 1000MHz, NF as low as 2.8dB, and power output as high as +15dBm.

Prices start at only \$13.95, including screening, thermal shock -55°C to $+100^{\circ}\text{C}$, fine and gross leak, and burn-in for 96 hours at 100°C under normal operating voltage and current.

Internally the MAN amplifiers consist of two stages, including coupling capacitors.

A designer's delight, with all components self-contained. Just connect to a dc supply voltage and you are ready to go.

The new MAN-amplifiers series...
another Mini-Circuits' price/performance breakthrough.

MODEL	FREQ. RANGE (MHz)	GAIN dB		MAX. OUT/PWR†	NF dB	DC PWR 12V,	PRICE \$ ea.
	f_L to f_U	min	flatness††	dBm	(typ)	mA	(10-24)
MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95
◇MAN-1HLN	10-500	10	0.8	15	3.7	70	15.95
*MAN-1AD	5.500	16	0.5	6	7.2	85	24.95

††Midband $10f_L$ to $f_U/2$, $\pm 0.5\text{dB}$

†dB Gain Compression

◇Case Height 0.3 In.

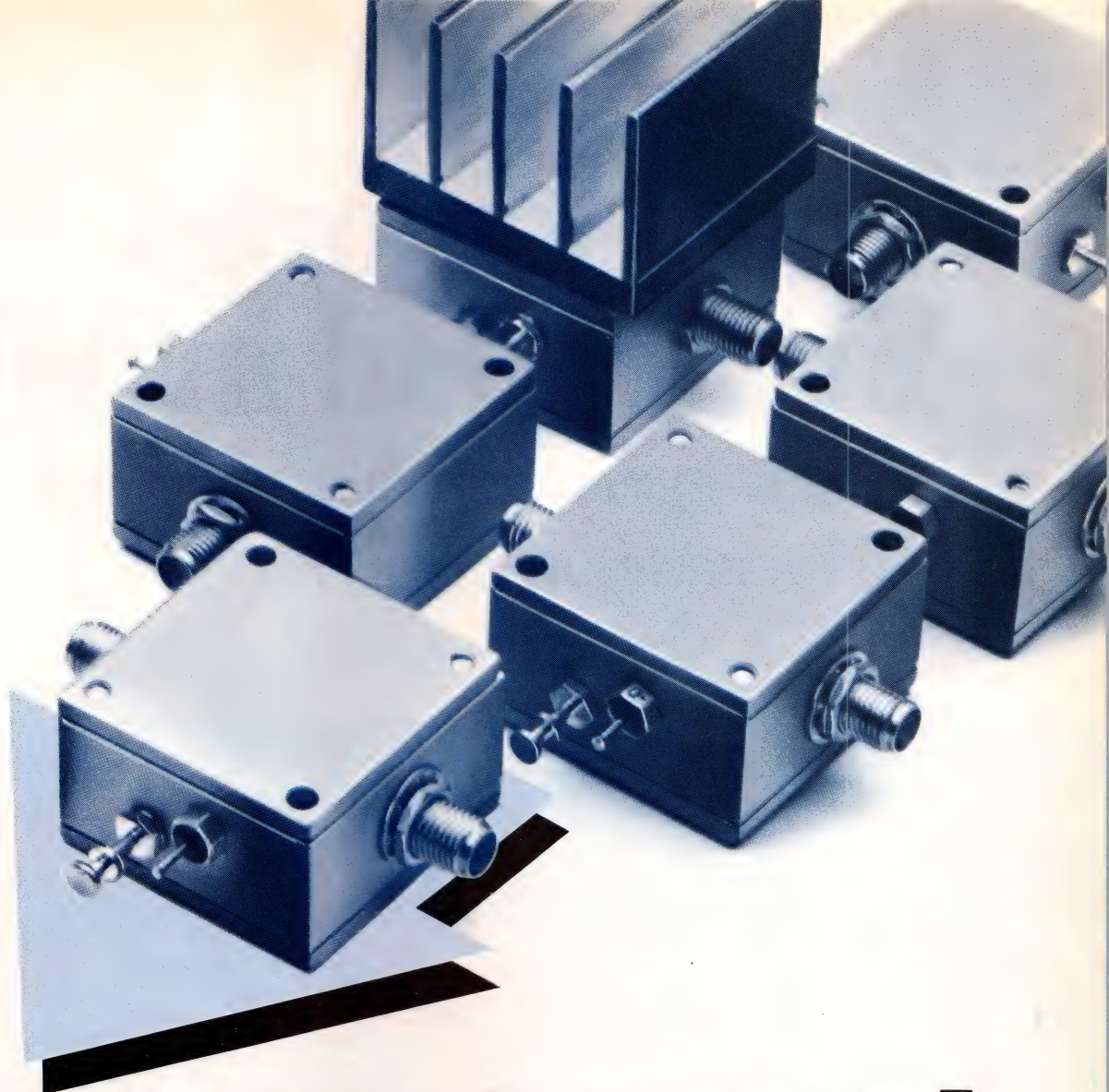
Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.

*Active Directivity (difference between reverse and forward gain) 30 dB typ.

finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156



Amplifier Arsenal

50KHz—2000MHz, Low Noise 250mW output Gain Controlled from **\$69.95**

Our ZFL-2000 miniature wideband amplifier hit a bulls-eye when we introduced it last year. Now we've added more models to offer you a competitive edge in the continuing battle for systems improvement.

The ZFL-2000, flat from 10 to 2000MHz, delivers +17dBm output and is priced at only \$219.

Need more output? Our ZFL-1000H, flat from 10 to 1000MHz, delivers +20dBm output.

Is low noise a critical factor? Our ZFL-500LN and 1000LN boast a 2.9dB NF.

Variable gain important? Our ZFL-1000G, flat from 10 to 1000MHz, delivers +3dBm output with 30dB gain control while maintaining constant input/output impedance. The ZFL-1000GH spans 10-1200 MHz, has 30 dB gain control, and +9dBm output.

Searching for a high-quality, low-cost amplifier? Our ZFL-500 flat from 50KHz to 500MHz, delivers +10dBm output for the unbelievable low price of only \$69.95. Need to go higher in frequency? Consider the ZFL-750, from 0.2 to 750MHz, for only \$74.95. Or the \$79.95 ZFL-1000, spanning 0.1 to 1000 MHz. One week delivery...one year guarantee.

SPECIFICATIONS

MODEL	FREQUENCY MHz	GAIN, dB (min.)	MAX. POWER OUTPUT dBm(typ)	NF dB(typ)	PRICE \$ Qty. (1-9) Ea.
ZFL-500	0.05-500	20	+9	5.3	69.95
ZFL-500LN	0.1-500	24	+5	2.9	79.95
ZFL-750	0.2-750	18	+9	6.0	74.95
ZFL-1000	0.1-1000	17	+9	6.0	79.95
ZFL-1000G*	10-1000	17	+3	12.0	199.00
ZFL-1000GH*	10-1200	24	+9	15.0	219.00
ZFL-1000H	10-1000	28	+20	5.0	219.00
ZFL-500HLN	10-500	19	+16	3.8	99.95
ZFL-1000LN	0.1-1000	20	+3	2.9	89.95
ZFL-1000VH	10-1000	20	+26	4.5	229.00
ZFL-2000	10-2000	20	+17**	7.0	219.00

* 30dB gain control

**+15dBm below 1000MHz

finding new ways...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation

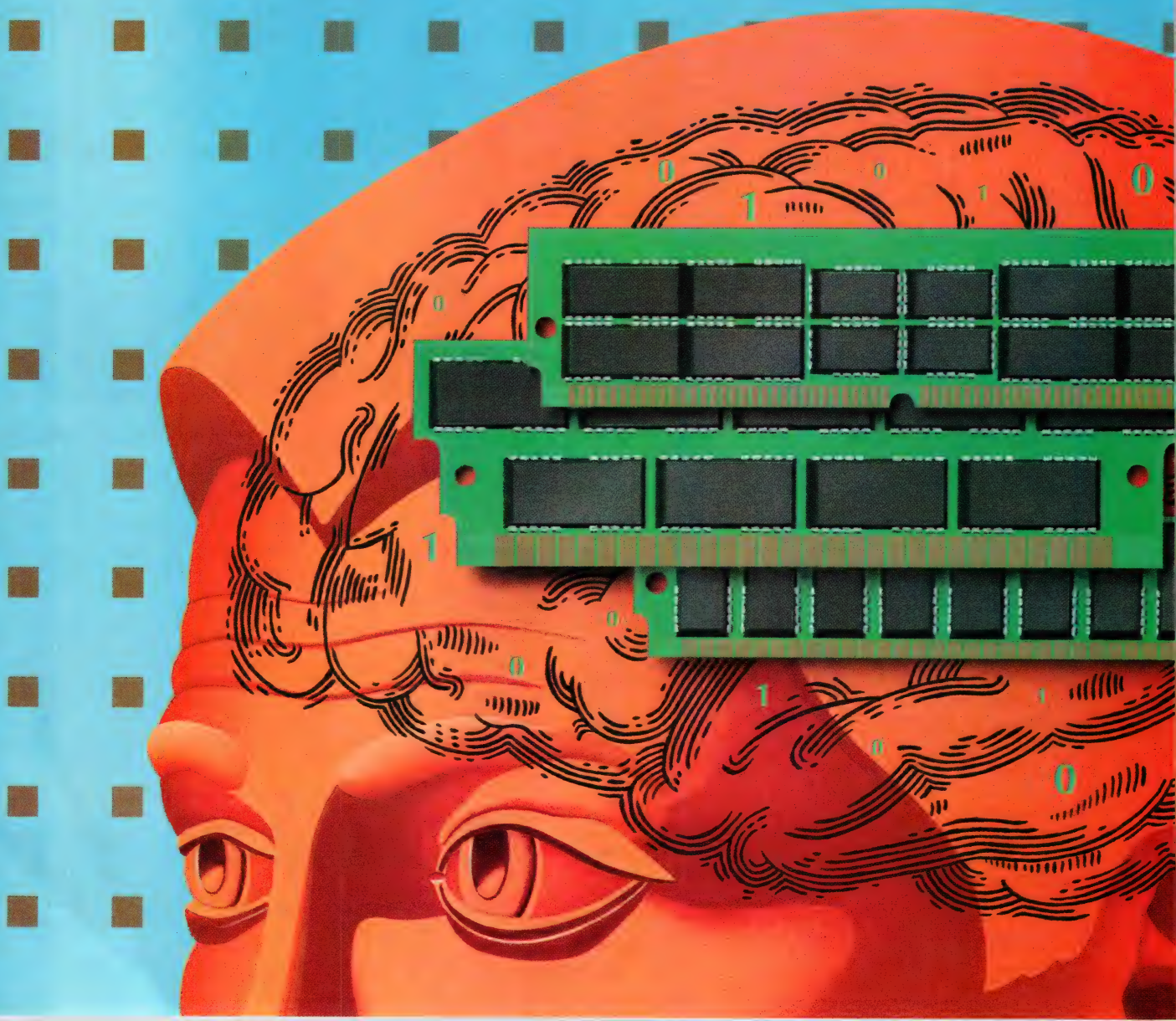
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

WE ACCEPT AMERICAN EXPRESS

C101 REV.G

The Memories You've Had in Mind

for next-generation designs: Oki's
new-generation SIMMs[®]



Speed. Low power consumption. Broad selection. Package and assembly expertise from one supplier. All essential memory ingredients for your next-generation designs. And they're all available from Oki Semiconductor. Our new-generation memory modules—built with the most advanced surface mount technology—have been designed with your future applications in mind.

We offer standard x8 and x9 SIMMs and JEDEC standard-dimension x36, x32, and x18s with customer specific pin-outs. No need to design your system around a standard part. Just specify the custom

Oki SIMM that matches the design you have in mind. Our entire memory family is manufactured in an ultramodern, Class 1 facility, dedicated to supplying the industry's highest quality memory devices.

For next-generation designs, we offer enhanced high-capacity DRAMs. Built with submicron technology on 6-inch wafers, our 1-Mbit DRAM has all the high-performance features you need. 80-ns speed. 20% less power consumption for higher density packaging. Plus excellent noise immunity for less bypassing and easier design.

But that's not all. Our 4-Mbit DRAM is also available for your latest system designs. And because the 4-Mbit x9 has the same pin-outs and dimensions as our 1-Mbit x9, it easily replaces the 1-Meg, increasing memory fourfold without any board redesign.

If you need high-performance features from a full-line memory family—Oki Semiconductor is your supplier. Call your local Oki field office today for more information on the next-generation memories you've been thinking about.

		Package	
Organization	Speeds	Outline	Pinout
256K x 8b	80ns, 100ns, 120ns	JEDEC	JEDEC
256K x 9b	80ns, 100ns, 120ns	JEDEC	JEDEC
1 Meg x 8b	80ns, 100ns, 120ns	JEDEC	JEDEC
1 Meg x 9b	80ns, 100ns, 120ns	JEDEC	JEDEC
256K x 36b	80ns, 100ns, 120ns	JEDEC	Custom
512K x 36b	80ns, 100ns, 120ns	JEDEC	Custom
Custom	80ns, 100ns, 120ns	Custom	Custom

Call for pricing & part numbers

So. Calif.
(Irvine)
714/752-1843
(Sherman Oaks)
818/990-3394
No. Calif.
(San Jose)
408/244-9666
Boca Raton, FL
407/394-6099

Atlanta, GA
(Norcross)
404/448-7111
Chicago, IL
(Rolling Meadows)
312/870-1400
Boston, MA
(Stoneham)
617/279-0293
Detroit, MI
(Livonia)
313/464-7200

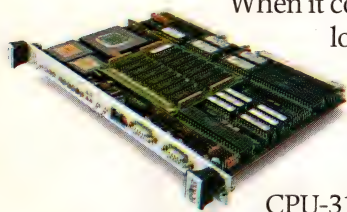
New York, NY
(Poughkeepsie)
914/473-8044
Philadelphia, PA
(Horsham)
215/674-9511
Dallas, TX
(Richardson)
214/690-6868

OKI
SEMICONDUCTOR

Imagine it's trans and you'll understand



Introducing a 68030 VME board that makes your applications take off.



When it comes to transporting a plane-load of people at Mach 2, nothing beats the Concorde. It's the ultimate expression of throughput. It's also the idea behind

CPU-31, the newest member of our VME/PLUS family. Transporting busloads of data at maximum speed. Providing throughput like you've never seen in a 68030-based board.

All thanks to CPU-31's unique architecture. Starting with a full megabyte of synchronized dual-port

SRAM. It's designed to provide maximum performance during dual-port, no-wait-state memory accesses. Which makes your real-time applications fly.

Then there's the VME Subsystem Bus (VSB). Which gives you wide open access to localized resources without having to contend with additional overhead traffic. It's like having an extra runway reserved only for priority flights.

And because its 32-bit DMA has a 22 MB per second transfer rate, the CPU is easily off-loaded and freed-up for other tasks.

Throughput is further improved by two message broadcasting channels, allowing simultaneous data transmission to more than one CPU. Up to 256 messages can be defined and transmitted to as many as 20 boards.

porting data our new VME board.



And if that still isn't enough, eight mailbox interrupts also support interprocessor communications. So you get loads of flexibility for designing multi-processing systems.

For the highest throughput, travel first class with our 20 MHz CPU-31. You'll get 1100K Whetstone and 6700 Dhrystone performance. Or business class with our 16.7 MHz version, for 900K Whetstone and 5600 Dhrystone speed.

Either way, you'll get the VMEPROM™ real-time multitasking kernel with debug monitor. It's designed to take full advantage of FORCE architecture. Best of all, it's yours at no extra charge.

And to bring your project in for a smooth landing, FORCE provides a total system solution. Including third party software along with FORCE integration

support. Plus access to our regional support staff.

For more information on the CPU-31, call FORCE at 1-800-BEST-VME. Or fax us at (408) 374-1146 for an immediate response.

If you want the highest 68030 throughput anywhere, now's the time to get on board.



VME at its best.

FORCE COMPUTERS INC.
3165 Winchester Blvd.
Campbell, CA 95008-6557
Phone (408) 370-6300
Fax (408) 374-1146

FORCE COMPUTERS GmbH
Prof.-Messerschmitt-Strasse 1
D-8014 Neubiberg/Munich
Tel: (089) 6 08 14-0 Tlx: 524 190 forc-d
Fax: (089) 6 09 77 93

©1989 FORCE COMPUTERS INC.
VMEPROM is a trademark of Eyring Research Institute, Inc. VME/PLUS is a trademark of Force Computers, Inc.

88000 WAYS TO GET TO UNIX V.4 FASTER.

The future of computer operating systems is UNIX®, and the fastest way of getting to its next release, V.4, is Motorola's 88000 microprocessor.

While other companies seem to promise the same thing, only Motorola's 88000 has the solution. *Today.*

Because the 88000 has the only published Binary Compatibility Standard (BCS) on UNIX System V 3.2.

The 88000 BCS assures manufacturers of having application software on hand immediately by enabling release 3.2 application software to execute under release 4.

That's one reason AT&T chose the 88000 BCS as the early development platform for their V.4 Application Binary Interface.

Designers moving software for other hardware platforms will spend months recompiling.

We think software vendors have better things to do with their time.

And systems manufacturers more important things to do than wait for them.

Don't waste another second. Contact us today.



MOTOROLA

© 1989, Motorola, Inc.

All names indicated by ® are registered trademarks of their respective holders.

SIGNALS & NOISE

Frequency affects output impedance

Sergio Franco proposes (EDN, June 8, 1989, pg 187) that you should compute the correct values for capacitors, such as 34.29 pF, because "empirical values do not necessarily guarantee optimum results." These values are supposed to give optimum results when you analyze an op-amp circuit in Spice. However, Mr Franco's analysis assumes that the output impedance of an op amp has a constant resistive value at all frequencies.

My data show that many op amps have low Z_{OUT} at moderate frequencies, but this Z_{OUT} can rise (inductively) at high frequencies. Some op amps start out with a high value of R_{OUT} , which falls (capacitively) to a lower value at high frequency. Because many op amps do not have a constant R_{OUT} at high frequencies, I find it necessary to breadboard and test the actual circuit rather than just trust that the computed values are correct, for the following reasons: An op amp's output impedance is not easy to express mathematically; makes the mathematical analysis quite messy; and tends to change value and thus affects the op amp's frequency response when the output changes from sourcing current to sinking current.

I do agree that Sergio's computations are a good place to start.
Robert A Pease
Staff Scientist
National Semiconductor
Santa Clara, CA

Pertinent points about PCPlot

Thank you for including PCPlot in the Technology Update "Draw your graphs on printers and plotters" (EDN, April 13, 1989, pg 53), which compared graphing-software packages. As PCPlot's author, I found the article informative and well written. Unfortunately, some errors occurred in the evaluation of

PCPlot. It was stated that PCPlot "produces plots with as many as 1000 points." This is not true. PCPlot produces plots with as many as 6000 points and allows as many as six data files (1000 points per data file) to be plotted on the same graph. This capability is an important factor for engineers who plot more than one set of data on the same graph.

It also stated, "Unfortunately, BV Engineering's programs don't let you store graphic images in files for later use." Our Plotter Driver Program enables you to save images in the native language of the plotter that you select (HPGL, DMPL, etc). Since these are common graphic-image formats, BV Engineering's programs do indeed support this important feature.

It was our intention to create a graphing program that's easy to learn and use. In PCPlot, we have accomplished that goal. Even untrained, nontechnical people can learn to use PCPlot in a matter of minutes.

Steve Sauls
BV Engineering
Riverside, CA

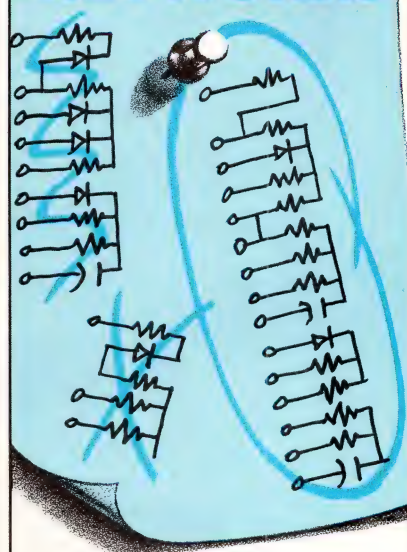
Who "belongs" in the US?

One day this fellow who was working in our department said, "Why don't these foreigners go back where they came from?" (See Jon Titus's editorial, "Send alien graduates home," EDN, October 27, 1988, pg 57.) I asked him casually, "John, where did you come from?" He replied that he was born here.

I asked him where his parents came from. He replied that they came from Poland. Then I said, "Why don't they go back home?" He said they didn't like it back home. Life and things were tough.

I remember this dialogue with John vividly. I told him, "John, tell me in what sense you have contributed more than I have to this country? I am more educated than you.

BRADFORD CUSTOM NETWORKS



Quick! Send us a sketch of the circuit you need.

We'll design a prototype network for your review and arrange for samples. Bradford specializes in resistor, capacitor, inductor and diode combinations...in space- and

cost-saving custom circuits.

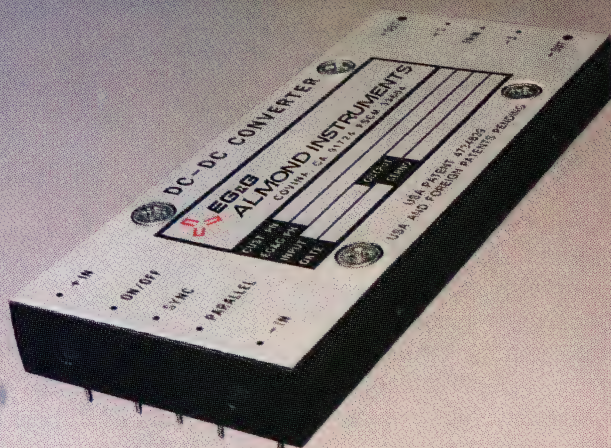
Standard or special packaging. Excellent operational stability ($\pm 1/2\% \Delta R/1,000$ hrs., typical). Get the kind of special attention that can accelerate your project and keep you under budget. Contact:

Bill Shaffer
Bradford Electronics, Inc.
... a VISHAY Company
550 High Street
Bradford, PA 16701-0930
(814) 362-5717



CIRCLE NO 29

Military DC-DC Converters



for High Power Density Applications

EG&G Almond Instruments MIL-SPEC DC-DC Converters offer military electronics designers great flexibility in DC power distribution and packaging:

- 100 Watt output @ 85°C baseplate
- Military DC inputs: 28VDC to 270VDC
- Standard DC outputs: 5VDC to 28VDC
- 1, 2, and 3 output models
- Full military qualification *
- Small size: 0.515 x 2.0 x 4.6 inches
- 230,000 hours MTBF @ 65°C baseplate, N₅
- 80% efficiency
- Remote sensing
- Fixed 100kHz switching frequency
- $\pm 5\%$ voltage adjust
- Remote ON/OFF
- Paralleling with current sharing
- N+1 redundancy
- External sync option

* Qualified for Army, Navy and Air Force combat platforms per applicable requirements of MIL-STD-454, NAVMAT P 4855-1, MIL-E-5400, MIL-E-16400, and DOD-STD-2000. Only MIL-SPEC screened parts are used. Derating is per P4855-1. Units are produced in a MIL-Q-9858A environment.

For cost and delivery information contact
David Adams, V.P. Marketing



EG&G

ALMOND INSTRUMENTS

1330 E. Cypress St., Covina, CA 91724 • (818) 967-9521 • FAX (818) 967-3151

SIGNALS & NOISE

I pay more taxes than you. I work harder than you. I teach and train. I don't smoke or drink. I don't sell or buy drugs. I am honest and more patriotic than you will ever be, because I know the value of freedom. I know the value of free expression. I will never sell the secrets of this country, and I will never pollute, destroy, or deface any part of this country. I will never belittle, disgrace, or expose any weakness of this country. This is one of the few countries where we, the people, can make it stronger. In most countries, this right is usurped by a few. I am thankful that I have the opportunity to be here and contribute in whatever fashion I can. I am very proud to be a naturalized citizen of the United States."

John said he never thought of it that way. Later, we became good friends.

I cannot say this about Jon Titus. I believe, however, he has been enlightened by the letters of Bill Geary and Mike Lynn (Signals & Noise, EDN, May 25, 1989, pg 33). Well done, Bill and Mike.

M Kamal Khan

*National Semiconductor
South Portland, ME*

Missing phone numbers

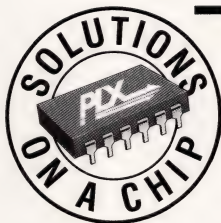
In the Technology Update, "Software tools handle all μ P traffic" (EDN, June 8, 1989, pg 89), the following phone numbers were inadvertently overlooked: (800) 245-6717 for PC-SIG in Sunnyvale, CA; and (206) 641-7978 for the Library Bulletin Board System in Seattle, WA.

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

Small Space Bus Interface.

64
MILLIAMP
DRIVER
ON BOARD



Clip this coupon and you could save 4 square inches of board space, or more, on your VME, VSB or Micro Channel bus interface.

Save precious board space.
Start using PLX high-drive bus interface ICs.

Just one 24-pin PLX IC does the job of 6 ICs: a PAL, plus high current drivers, Schmitt trigger buffers, delay lines, and registers.

Take advantage of our sample offer for two free ICs and discover how compact and efficient a bus interface can be.

PLX: I accept your offer, please send me a free sample of the two units checked below. (*Offer expires 12/31/89*)

- | | |
|--|--|
| <input type="checkbox"/> VME1220 Master Controller | <input type="checkbox"/> VME4000 Interrupt Handler |
| <input type="checkbox"/> VME2000 Slave Controller | <input type="checkbox"/> VSB1200 Master Controller |
| <input type="checkbox"/> VME3000 Interrupter | <input type="checkbox"/> VSB2000 Slave Controller |
| | <input type="checkbox"/> MCA1200 MC Bus Master |

()
BUSINESS PHONE

NAME

COMPANY

ADDRESS

Attach coupon to business card or letterhead and mail to:
PLX Technology, 625 Clyde Ave., Mountain View, CA
94043. Phone 1-800-759-3735.



PLX is a trademark of PLX Technologies, Inc. Other brands or product names are trademarks of their respective holders.

EDN081789

TOSHIBA TLCS 47/470. ARE YOU IMPRESSED BY VARIETY?

If we're talking variety,
this one's hard to beat.



In the Toshiba TLCS 47/470 microcontroller range, there's one for just about every standard application you can think of. Which is pretty good to know.

Behind this diversity lies the know-how, quality and experience of one of the world's leading semiconductor manufacturers. Which is pretty important to know.

Our development engineers can also help find solutions to your individual design tasks. Because unlike the blue peacock, our variety isn't just for show. We know it takes more than that to be convincing.

Pavo cristatus, the blue peacock.

CIRCLE NO 10

IN TOUCH WITH TOMORROW

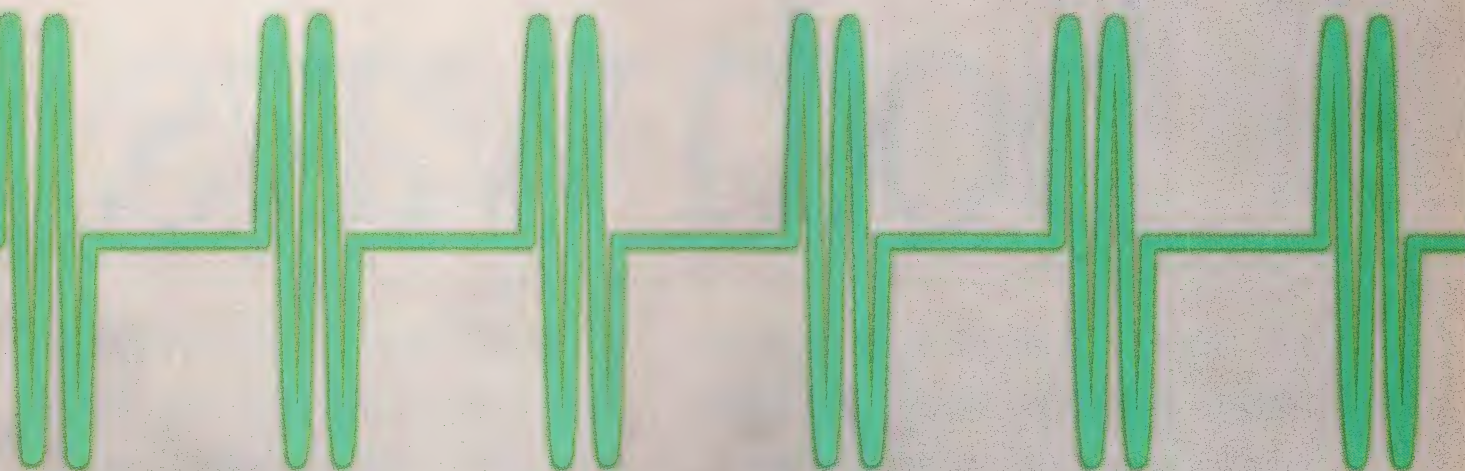
TOSHIBA

Full information about the TD 74/BI-CMOS series is available from:
Toshiba Electronics Europe GmbH,
Hansa Allee 181, D-4000 Düsseldorf 11,
West Germany, Phone: 49 211 52 96-0

TOSHIBA Electronics Europe GmbH, Düsseldorf Headquarter, Hansaallee 181, D-4000 Düsseldorf 11, Tel.: 0211/5296-0 · TOSHIBA (UK) Ltd., Watchmoor Business Park, Blackwater Valley Road, Camberley Surrey, Tel.: (01) 0276-694600 · TOSHIBA Electronics Italiana S.R.L., Centro Direzionale Colleoni, Palazzo Orione Ingresso 3°, I-20041 Agrate Brianza Milano, Tel.: 0-39-638891 · TOSHIBA Electronics Espana S.A., Planta Ga, Torre II, Torres de Colon, Plaza de Colon 2, Madrid, Tel.: (0034) 1-5325840 · TOSHIBA Electronics France, Immeuble Robert Schumann, 3 Rue de Rome, F-93561 Rosny Sous Bois Cedex, Tel.: (00-33) 1-489420 · TOSHIBA Electronics Scandinavia AB, P.O. Box 15031, S-16115 Bromma, Sweden, Tel.: (46-0) 8-7040900 · ALCOM Electronics B.V., NL-2808 LJ Capelle/IJssel, Tel.: 0031-10-4519533, ITT MULTICOMPONENTS, NL-2722 MA Zoetermeer, Tel.: 0031-79-410141 · AXCO GMBH, A-1232 Vienna 12, Tel.: 0043-222-61063 · D + D Electronics PVBA, B-2020 Antwerpen, Tel.: 0032-3-8277934 · ITT MULTICOMPONENTS, B-1080 Brussels, Tel.: 0032-2-4232911 · W. MOOR AG, CH-8105 Regensdorf, Tel.: 0041-1-8406644


PHILIPS

The source for every waveform!



Three synthesizer/function generators from DC to 50 MHz

Whatever the waveform, these versatile synthesizer/function generators from the Philips/Fluke alliance will give it to you — precisely. The top-of-the-line PM 5193 offers you **eight standard waveforms**, including positive and negative pulses; all instantly selectable at the touch of a button.

Frequency range extends right up to 50 MHz, with a maximum resolution of 0.1 mHz. While **quartz crystal precision** ensures long-term reference performance, with settings reproducible to within 1 p.p.m.

Precise signal setting also means a **wide choice of**

modulation modes. The PM 5193 gives you AM, FM, gating and counted burst, plus linear and logarithmic sweeps with a choice of three sweep modes.

Making operation simple, the PM 5193 is **fully programmable** — from the keypad, or via the standard, built-in IEEE-488 interface. A non-volatile memory allows instant storage and recall of up to 10 complete settings.

The PM 5191 and PM 5192 models are just as versatile, with frequency ranges of up to 2 MHz and 20 MHz, respectively.

These high-performance instruments are part of a

full range of function, pulse and signal generators from the Philips/Fluke global alliance — the source for every waveform you need.

For further information, call your local supplier:

Austria (0222) 60101-1772, Belgium (02) 5256692/94, Denmark (01) 572222, Finland (0) 5026371, France (1) 49428080, Germany (561) 501466, Great Britain (223) 358866, Ireland (61) 330333, Italy (039) 3635240/8/9, Netherlands (13) 352455, Norway* (2) 680200, Portugal* (1) 683121, Spain (1) 4042200, Sweden (8) 7031000, Switzerland (1) 4882390.

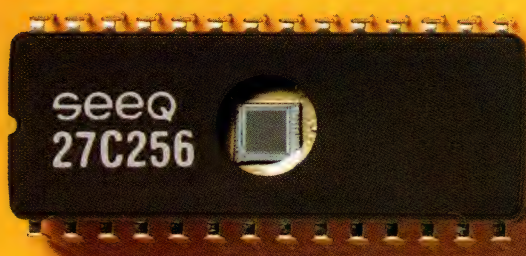
*For Philips products only.

For countries not listed, write to: Philips I&E, T&M Department, Building HKF, 5600 MD Eindhoven, The Netherlands.


PHILIPS

Have it both ways.

It's the best of both approaches: the high density (512K and 1Mb) FLASH with the low power and cost-effectiveness of UVEPROMs, and the fast in-circuit reprogrammability and packaging options of EEPROMs.



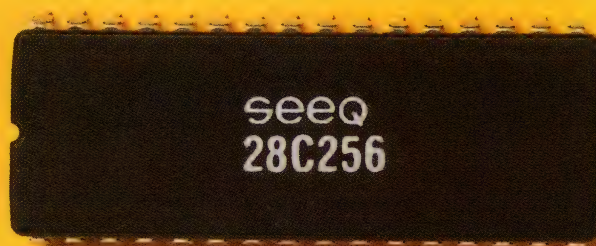
The memory density of a UVEPROM.

In a device that's priced at a fraction of the cost of EEPROMs.

It's the new FLASH EEPROM from SEEQ. And along with high density and low cost, it delivers the same kind of flexibility you need to get your design created. And implemented.

The combination of our FLASH cell architecture and EEPROM-type erasure make possible this chip's fast erase speed. The 1Mb memory array is divided into 128 sectors of 1024 bytes each. And each sector can be individually erased and reprogrammed. You can also remove the entire memory contents with chip erase. Typical erase time is 2 seconds. And write time is just 1ms per byte.

You can get our 1Mb FLASH in ceramic and plastic surface mount packages, as well as both plastic and



The electrical erasure of an EEPROM.



seeQ
48F010 FLASH

ceramic DIPs. The DIP packages are in a 32-pin JEDEC format so you can easily upgrade in density from 512K through 2Mbit with no hardware changes.

All of which make FLASH perfect for hard disc replacement in laptop computers and portable instruments, program memory in point-of-sale terminals and industrial controllers.

So next time you look at program

memory, check out our latest FLASH. For more information just call us toll free at **1-800-3EEPROM**. Or write SEEQ Technology, Inc., 1849 Fortune Drive, San Jose, CA 95131.

You'll see that having it both ways is the best way.

seeQ

E² is our middle name.

Isolated Power MOSFETS

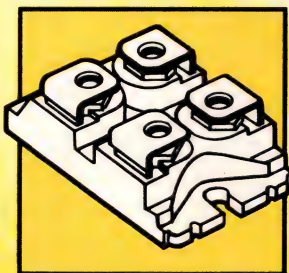
1000 Volts, 14mOhm, 3 Packages

One Leader.

Switch to the leader in POWER MOSFET isolated package technology, SGS-THOMSON Microelectronics, from day one you'll get isolated power that will help blast you right past your competition. The SGS-THOMSON range of power MOSFET devices in the emerging industry standard ISOTOP™ power packages is truly exceptional ranging from high voltage devices like the 1000V TSD5MG40 to high current devices like the 14mOhm TSD4M150.

The high performance ISOTOP package takes up no more real estate than a standard TO-3 but it has advantages that leave the others standing.

- 2.5 kVrms internal insulation
- Very low J-C thermal resistance $<0.25^{\circ}\text{C/W}$
- Low internal parasitic inductance $<5\text{nH}$
- Low parasitic Capacitance $<45\text{pF}$
- Improved reliability
- Reduced EMI and RFI
- Multiple mounting on a single heatsink
- Connections on track side of board
- Easy assembly
- One device replaces 4 or 5 standard devices



TM: ISOTOP, ISOWATT218 and ISOWATT220 are trademarks of the SGS-THOMSON Microelectronics Group.

Now read the bottom line - Lower costs.

If it all sounds too good to be true just check out how much it costs to use standard devices. First you'll need 4 or 5 plus all their isolating components, plus the extra heatsinks, plus the extra space you'll need to mount them. Then add on the cost of assembling all the different parts plus the cost of the extra inventory.

And even if your application is only using a couple of standard TO-218 or TO-220 packages, do a straight-device-for-device swap with SGS-THOMSON's ISOWATT218™ and ISOWATT220™ isolated versions and you can still improve your price/performance ratio. Switch to the leader in Power MOSFET isolated package technology now and from day one you'll get isolated power that will help you power right past your competition.



SGS-THOMSON Microelectronics

7, Avenue Gallieni - BP93

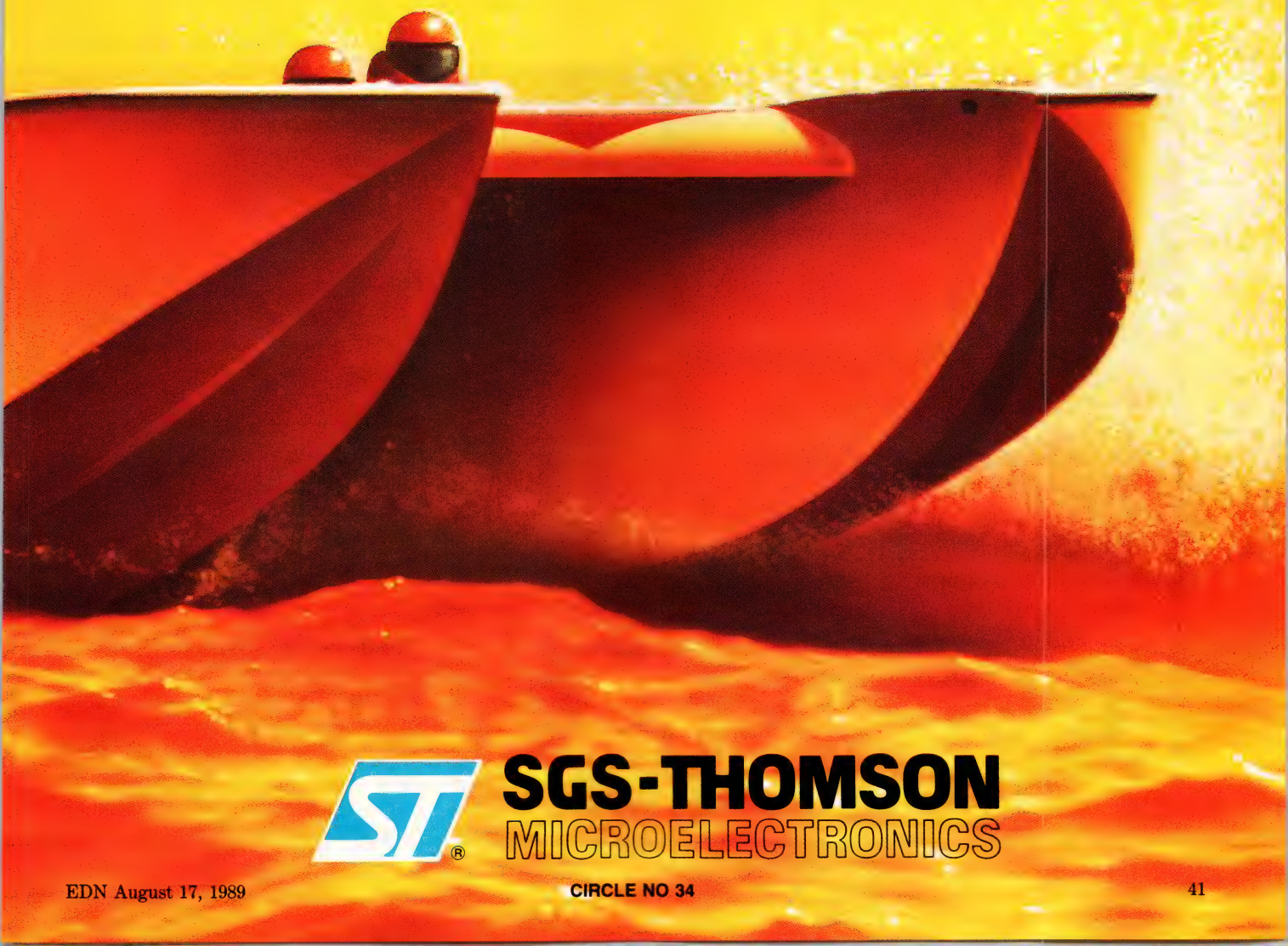
94253 Gentilly Cedex

Tel: (33-1) 47407575 - Fax: (33-1) 47407910

Telex: 632570 STMHQ

SGS-THOMSON

The Power to Win.



SGS-THOMSON
MICROELECTRONICS

PROCESS CONTROLS Single & Dual Channel Control

Menu Selectable

- RTD's
- Thermocouples
- Voltage
- Current
- Wet/Dry Bulb
- Pressure
- etc.



Also Included

- Ramping
- Chart Outputs
- Local Programming
- Battery Backup

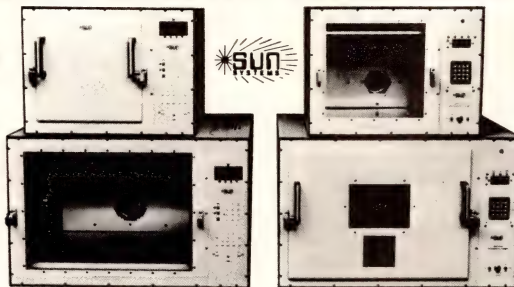


Sun Electronic Systems, Inc.

1601 N.W. 38th Avenue, Fort Lauderdale, Florida 33311 • (305) 587-5577 • Fax 587- 0450

ENVIRONMENTAL TEST CHAMBERS

- Local Programing
- User Friendly
- Ramping
- Dual Probes
- Menu Set-ups



- RS232/422
- Serial User Port
- GPIB/IEEE-488
- Chart Outputs
- Digital User Port

Sun Electronic Systems, Inc.

1601 N.W. 38th Avenue, Fort Lauderdale, Florida 33311 • (305) 587-5577 • Fax 587- 0450

CIRCLE NO 35

The company that supplies parts with zero defects now can supply product in a true voidless package.

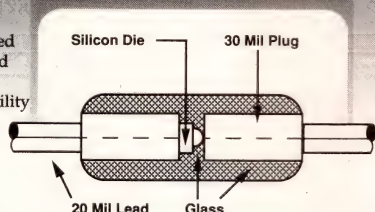
State-of-the-Art
VOIDLESS
Construction

FEATURES

- Voidless construction
- Thermally-matched
- Metallurgically bonded
- No PIND test required
- DO-35 package
- The ultimate in reliability

SPECIAL FEATURES

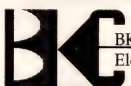
- Available to Source Control Drawings
- Processing available to JAN, JANTX, JANTXV and JAN S Quality Levels



RELIABILITY DATA

- Capable of passing thermal shock -196° C to +150° C (liquid to liquid)
- Capable of passing 2000 cycles of temperature cycling -65° C to +175° C
- Solder plate surpasses requirements of MIL-STD 202, Method 208
- 8 hour Steam Age Test.

Now available in
Voidless construction



BKC International
Electronics Inc.

6 Lake Street
Lawrence, MA
USA 01841

Phone (508) 681-0392 • Fax (508) 681-9135
Call or write for a catalog of all our fine products.

1N3595	1N3595-1
1N4148-1	1N4150-1
1N4153-1	1N4454-1
1N5194	1N5195
1N750A-1	1N759A-1
1N962B-1	1N973B-1

CIRCLE NO 36

CALENDAR

Data Communication Concepts (seminar), Los Angeles, CA. Technology Transfer Institute, 741 10th St, Santa Monica, CA 90402. (213) 394-8305. August 23 to 25.

11th Quartz Devices Conference and Exhibition, Kansas City, MO. Electronic Industries Association, 1722 Eye St NW, Washington, DC 20006. (202) 457-4981. August 28 to 31.

International Test Conference 1989, Washington, DC. International Test Conference, Box 264, Mt Freedom, NJ 07970. (201) 895-5260. FAX 201-895-7265. August 29 to 31.

Surface Mount '89, San Jose, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. August 29 to 31.

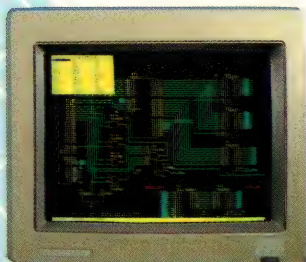
Real-time Structured Analysis & Design (short course), Washington, DC. John Valenti, Integrated Computer Systems, 6053 W Century Blvd, Los Angeles, CA 90045. (800) 421-8166; in CA, (213) 417-9700. FAX 213-410-2952. August 29 to September 1.

Midcon/89, Rosemont, IL. Midcon/89, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. September 12 to 14.

Aerospace & Electronics '89 (conference), Santa Clara, CA. National Computer Graphics Association, 2722 Merrilee Dr, Suite 200, Fairfax, VA 22031. (703) 698-9600. FAX 703-560-2752. September 12 to 15.

1989 Annual Conference of the International Federation of Consulting Engineers, Washington, DC. Jeanne Quick, American Consulting Engineers Council, 1015 15th St NW, Washington, DC 20005. (202) 347-7474. September 24 to 27.

Protel, now we give you rip-up without the rip-off



*Protel Schematic Easy
digital and analog circuit
design for only \$495*



*Protel Autotrax, complete PCB
layout with automatic component
placement and routing. \$995*

We don't think that you should have to spend a fortune to get serious about PCB design. That's why our low-cost family of PC-based CAD packages is structured around the needs of the professional designer. Protel Schematic gets you started with a straight-forward, flat sheet drawing environment. Autotrax loads your schematic netlist for automated PCB layout. And now, Protel Traxstar, a rip-up router that handles 6 layers and over 200 ICs yet runs on your XT, AT or 386 compatible. Find out why nearly 10,000 users worldwide agree. Protel is serious about your PCB productivity.



Protel Traxstar, High-performance rip-up and re-try router for Protel Autotrax PCB files. Introductory price \$995.

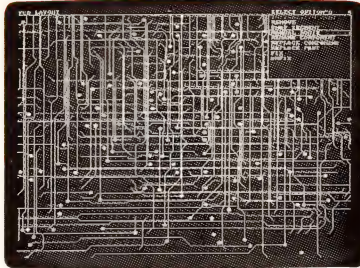


Technology

50 AIRPORT PARKWAY, SAN JOSE CA 95110 USA
Toll free: (800) 544-4186 in CA (408) 437-7771 Fax: (408) 437-4913
and Distributors Worldwide

POWER & PRICE... GUARANTEED

\$995 PCB CAD SOFTWARE



MAXI/PC is a great value! It includes schematic capture, automatic component placement, automatic and interactive routing, and manufacturing outputs. It's backed by a 30 day, money back, no risk guarantee. To order MAXI/PC, call (508) 692-4900. **MAXI/PC** PCB CAD SOFTWARE

RACAL RACAL-REDAC

238 Littleton Road, P.O. Box 365
Westford, MA 01886-9984

CIRCLE NO 164



Free MμShield Magnetic Shielding Catalog

For customized shielding, MμShield materials from stock, and consultation services, contact MμShield Products Division, Bomco, Inc., Route 128, Blackburn Circle, Gloucester, MA 01930. Phone 508/283-9000. Fax 508/283-2882.

bomco
Excellence In Metal Forming

CIRCLE NO 137

CALENDAR

Expo SMT International, Las Vegas, NV. Expo SMT, Box 1869, Los Gatos, CA 95031. (408) 354-0700. FAX 408-354-1036. September 25 to 27.

Diskcon, San Jose, CA. Julie Sunseri, 710 Lakeway, Suite 170, Sunnyvale, CA 94086. (408) 720-9352. FAX 408-736-2523. September 26 to 27.

IEEE International Conference on Computer Design (ICCD '89), Cambridge, MA. Giovanni De Micheli, Center for Integrated Systems, Room 129, Stanford University, Stanford, CA 94305. (415) 725-3632. October 2 to 4.

Electronic Imaging Conference East, Boston MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. October 2 to 5.

20th Korea Electronics Show, Seoul, Korea. Joseph Burke, US Department of Commerce, Washington, DC 20230. (202) 377-5014. October 7 to 12.

Systems 89, Munich, West Germany. Gerald Kallman, Kallman Associates, 5 Maple Ct, Ridgewood, NJ 07450. (201) 652-7070. FAX 201-652-3898. October 16 to 20.

Northcon/89, Portland, OR. Northcon/89, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. October 17 to 19.

Supercomputing World, San Francisco, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. October 17 to 20.

Unix Expo '89, New York, NY. National Expositions Company, 15 W 39th St, New York, NY 10018. (212) 391-9111. FAX 212-819-0755. November 1 to 3.



The program in a switch.

Introducing Vivisun Series 2000, the programmable display pushbutton system that interfaces the operator with the host computer. The user friendly LED dot-matrix displays can display any graphics or alpha-numerics and are available in green, red or amber. They can efficiently guide the operator through any complex sequence, such as a checklist, with no errors and no wasted time.

They also simplify operator training as well as control panel design. Four Vivisun Series 2000

switches can replace 50 or more dedicated switches and the wiring that goes with them. In short, Vivisun Series 2000 gives you more control over everything including your costs.

Contact us today.



AEROSPACE OPTICS INC.

3201 Sandy Lane, Fort Worth, Texas 76112
(817) 451-1141 • Telex 75-8461 • Fax (817) 654-3405

SERIES
VIVISUN 2000™



Programmable display switches. Making the complex simple.

"Do we have to have a different supplier for every



TOSHIBA AMERICA'S PRINCIPAL ELECTRONIC COMPONENTS • MOS INTEGRATED CIRCUITS: DYNAMIC RAMS – DRAMs, Video RAMs, Memory Modules. STATIC RAMS – Pseudo/Static SRAMs, High-Speed SRAMs. NON-VOLATILE MEMORY – EEPROMs, EPROMs, OTPs, Mask ROMs. MOS LOGIC ICS – Standard CMOS Logic Series: 4000/4500, 74HC/HCT, 74AC/ACT, New 74BC BiCMOS series. MICROCOMPUTERS – Microcontrollers, Microprocessors, Microperipherals, Development Support Systems. ASIC – Gate Arrays, Standard Cells, Megacell, Full Custom. SPECIFIC APPLICATIONS – Speech LSIs, Telecom Devices, Disk Chips, Graphics Products. **DISCRETE DEVICES AND BIPOLAR ICS:** SMALL SIGNAL DEVICES – Transistors, Diodes. POWER DEVICES – Power Transistors, Power MOS FETs, Insulated Gate Bipolar Transistors (IGBT), Giant Transistor (GTR) modules, Rectifiers, Gate Turn-Off Thyristor (GTO). OPTOELECTRONIC DEVICES – LED Lamps, Displays, Modules, Laser Diodes, Opto Couplers. BIPOLAR ICS – LSIs, Voltage Regulators, OP AMPs, Timers, Motor Controllers and IC Drivers, Interface Drivers. CHARGE-COUPLED DEVICES – Linear Image Sensors. **ELECTRON TUBES & DEVICES:** ELECTRON TUBES – Cathode Ray Tubes, Color Picture Tubes, Color Display Tubes, Monochrome Display

component?"

"I've been doing some research. Toshiba may be able to help."

"Toshiba? How are they going to get us out from under all this paperwork?"

"Well, let me put it this way: 95% of the electronics we need, they make."

"So, what's the bottom line?"

"Toshiba lets us reduce the costs of a broad supplier base, and actually improve quality at the same time."

"That's the answer I've been looking for."

There's no reason to go looking all over the map for components. Not when a phone call to Toshiba can deliver most, if not all, of the high quality components you need.

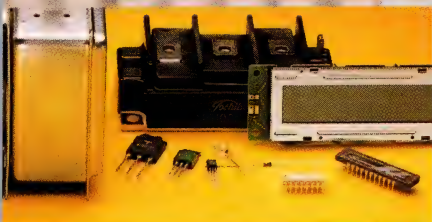
Thanks to Toshiba's CMOS expertise and standardized design and manufacturing processes, qualification time, money and paperwork can be dramatically cut by "family quals." And Toshiba is a step ahead in electron tube and display technology, where R&D efforts are second to none.

No matter what your systems needs are, Toshiba has probably got the solution. Whether you make electronic data processing, automotive, consumer, telecommunications or industrial equipment, Toshiba is there. The second largest manufacturer of semiconductors in the world, Toshiba specializes in Memory products including Standard ICs, ASICs, Logic and Processors. Plus, Toshiba also specializes in Display Devices (LEDs to LCDs and CRTs to Monitors). And Discrete Devices including Opto Couplers and Laser Diodes, all with Toshiba quality designed in.

With Toshiba's breadth and depth of products, you can feel confident of your supplier. You'll know where you stand on product availability and delivery, and you'll have all the advantages of a single, reliable business relationship with a company you trust.

To receive technical literature on any of Toshiba's electronic components, just call 1-800-888-0848 ext. 517 today.

Toshiba Electronic Components. We're the answer you've been looking for.



In Touch with Tomorrow
TOSHIBA

TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC.

©1989 Toshiba America, Inc.

HDQ-88-011

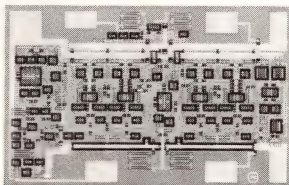
Tubes. MAGNETRONS. MEDICAL TUBES - X-Ray Tubes, Image Intensifier Tubes. MONITORS - Monochrome/Color Monitors and Chassis. LIQUID CRYSTAL DISPLAYS. OPTICAL DEVICES - Laser Diodes, Fiber Optic Links (TOSLINK). SAW DEVICES - Filters, Resonators. MAGNETIC MEDIA - BaFe Floppy Disk Media. **TOSHIBA AMERICA'S PRINCIPAL ELECTRONIC COMPONENTS - MOS INTEGRATED CIRCUITS:** DYNAMIC RAMS - DRAMS, Video RAMs, Memory Modules. STATIC RAMS - Pseudo/Static SRAMs, High-Speed SRAMs. NON-VOLATILE MEMORY - EEPROMs, EPROMs, OTPs, Mask ROMs. MOS LOGIC ICS - Standard C'MOS Logic Series: 4000/4500, 74HC/HCT, 74AC/ACT, New 74BC BiCMOS series. MICROCOMPUTERS - Microcontrollers, Microprocessors, Microperipherals, Development Support Systems. ASIC - Gate Arrays, Standard Cells, Megacell, Full Custom. SPECIFIC APPLICATIONS - Speech LSIs, Telecom Devices, Disk Chips, Graphics Products. **DISCRETE DEVICES AND BIPOLAR ICS:** SMALL SIGNAL DEVICES - Transistors, Diodes. POWER DEVICES - Power Transistors, Power MOS FETs, Insulated Gate Bipolar Transistors (IGBT), Giant Transistor (GTR) modules, Rectifiers, Gate Turn-Off Thyristor (GTO). OPTOELECTRONIC DEVICES - LED Lamps, Displays, Modules, Laser Diodes,

NOW PUT A LITTLE AVANTEK MAGIC IN YOUR SYSTEM

**Avantek MagIC™
High Speed ICs
Enable Superior
System Designs**

magIC™

The new MagIC™ series of silicon bipolar MSI integrated circuits offer the best performance available from silicon ICs yet. The broadband, high frequency performance of these high-speed silicon ICs make them cost-effective alternatives to more expensive GaAs ICs. Avantek MagIC silicon ICs are manufactured with Avantek's proprietary 10-15 GHz F_t , 25 GHz F_{max} Isosat™ process for unsurpassed integration and performance at microwave frequencies. Avantek's MagIC series ICs presently consists of four product families: low noise amplifiers, active mixers, variable gain control amplifiers, and prescalers. These low-cost, high-speed silicon ICs are Avantek's magic solutions to your RF, microwave and light-wave system performance and cost problems.



High Performance, High Speed, Low Cost...

The INA-series of two-stage low-noise amplifiers presently consists of three models, offering:

- 3 dB bandwidths to 2.8 GHz



- Gains as high as 32 dB
- Noise figures as low as 1.7 dB
- Prices as low as \$22.00 each* in hermetic 70 mil surface mount package

The IAM-series of active mixer/amplifiers presently consists of two models, offering:

- RF and LO frequency range of .05 to 5.0 GHz
- Conversion gain as high as 15 dB
- LO power as low as -10 dBm
- Prices as low as \$16.00 each* in hermetic 180 mil surface mount package

The IVA-series of variable gain control amplifiers presently consists of two models, offering:

- 3 dB bandwidths to 3.0 GHz
- 30 dB gain control range

- Gains as high as 26 dB
- Prices as low as \$28.50 each* in hermetic 180 mil surface mount package

The IFD-series low phase noise static prescalers offer:

- Divide-by-4 to 5 GHz
- Low 125 mW Power Consumption
- Prices as low as \$18.50 each* in hermetic 100 mil surface mount package

*Price for 1000 piece quantities



MagIC™ ICs Are Available in Quantity for Volume Applications

Avantek presently produces more than 1,000,000 MMICs per month. So you can be assured the MagIC high speed ICs you need will be available to support your volume production programs. And, all MagIC silicon ICs are in stock at your local Avantek distributor.

For additional information, or the name and address of your local distributor, contact the regional sales office nearest you.

Regional Sales Offices

North America

Eastern: (301) 381-2600

Central: (312) 358-8963

Western: (805) 373-3870

European: (44) 276-685753



Magic Solutions in Silicon



AVANTEK

EDITORIAL

Awakening the giant



The quotation, "I fear that all we have done is to awaken a sleeping giant," is attributed to Admiral Isoroku Yamamoto, who led the Imperial Navy's attack on Pearl Harbor in 1941. How times change. Now, many members of Congress, along with leaders of aerospace and electronics industries, should be applying the quote to the Japanese. The recent debate surrounding the licensing of technology to Japan for the coproduction of the FSX fighter plane may be having the opposite effect of what US industries want.

Instead of restricting the flow of technology to Japan, the FSX agreement may now push the Japanese to develop their own military systems—without sharing their technology with the US. When Japan expressed interest in working with the US on the FSX project, the US Department of Defense thought that the project would be mutually beneficial. Japan would gain a much-needed fighter aircraft, and US companies would gain from Japanese production subcontracts. However, some critics suspected that the Japanese would not give US companies a "reasonable" share of contracts.

Also, recalling the sale of advanced milling machines to the USSR, some people charged that Japan could not be trusted to keep the military technology out of enemy hands. People such as former trade negotiator Clyde Prestowitz, Jr, worried that Japanese industries might adopt US technologies shared under the FSX program and use them to establish an indigenous aircraft industry—in competition with US aircraft manufacturers.

The Japanese may have wearied of the debate over the FSX project. Recently, an influential Japanese business group, the Keidanren, suggested that it was time for Japan to double the country's military research and development budget. In fact, senior Japanese military and government officials think that the US will start withholding critical technologies—particularly those with both military and civilian uses. Thus, instead of working on an equitable technology-transfer arrangement, we're pushing the Japanese to start developing their own technologies—technologies in which the US won't share.

The US electronics industry should learn a lesson from the FSX debacle. It is often better to work with foreign companies and establish relationships based on mutual trust and respect; to build relationships that work to each participant's benefit. For example, in the microprocessor arena there are several vendors—among them Intel and Motorola—that do not yet have second sources for their advanced microprocessors. Those companies seem unwilling to license their μ P technologies to domestic or foreign companies. Intel's arrangement with IBM is an exception. We doubt that IBM would continue to use Intel μ P chips in its personal computers unless it had an agreement to make Intel-designed μ P chips in IBM facilities.

Eventually, buyers will rebel at such technology or chip monopolies unless suppliers offer cross-license agreements. Such agreements don't always work out perfectly, but they seem preferable to adversarial sparring that turns customers and potential partners into direct competitors.



Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2),
1977, 1976, 1975
American Society of
Business Press Editors Award
1988, 1983, 1981

A handwritten signature in dark ink, reading "Jon Titus". The signature is fluid and cursive, with a large, sweeping "J" and "T".

Jon Titus
Editor

Test development today:

The write way



The right way



The right choice is HP's Interactive Test Generator for faster, easier test development.

If the task of writing code is taking you away from test engineering and turning you into a full-time programmer, you'll welcome a faster, easier method of test development.

Meet HP's new Interactive Test Generator (ITG) software. It gives you an easy-to-use interface and automatically writes complex code for your test systems. Simple mouse-controlled instrument panels and menu-driven commands make test development intuitive. No need for manuals when programming new or unfamiliar instruments. HP ITG chooses the right command and sends it... automatically.

With HP ITG, HP BASIC and an HP 9000 Series 300 computer, you'll cut development time dramatically. You can run your final programs on any HP BASIC workstation. Or on a PC, using HP's BASIC Language Processor.

Call for your FREE demo disk.

See for yourself how HP ITG works. Call your local HP sales office today. We'll send you a FREE demo disk. Right away.

There is a better way.



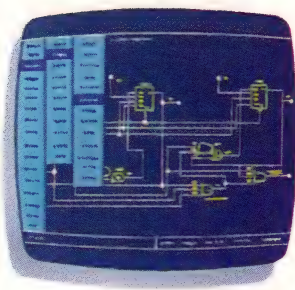
**HEWLETT
PACKARD**

Be Brilliant At In Production



7:05 am: Breakfast

Suddenly, between bites, the answer to that new system design jumps right into your brain. But how to make it work in silicon? Use an Actel field programmable gate array!



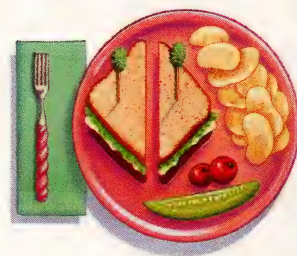
8:50 am: Design

You warm up the design program on your 386 and put in the final touches. Then a quick rule check and 25 MHz system simulation with the Action Logic System software.



11:00 am: Place & Route

You watch the system place and route all 1700 gates (out of 2000 available) in under 40 minutes. 100% automatically! A final timing check. Then think of something to do until lunch.



12:00 pm: Lunch

Remember lunch? Normal people actually *stop working* and have a nice meal — right in the middle of the day! With Actel's logic solution, this could become a habit.

ACTEL FIELD PROGRAMMABLE GATE ARRAYS

They're a feast for your imagination.

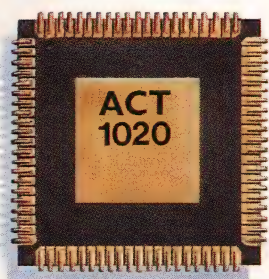
Actel's ACT™ 1 arrays bring you a completely new approach to logic integration. Not just another brand of EPLD, PAL®, or LCA™ chips. But true, high density, desktop configurable, channeled gate arrays.

They're the core of Actel's comprehensive design and production system for creating your own ASICs. Right at your desk. On a 386 PC or workstation. With familiar design tools like Viewlogic™, OrCAD™ and Mentor™.

And do it in hours instead of weeks. Even between meals.

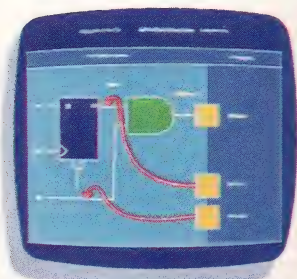
How? With features like 85% gate utilization. Guaranteed. Plus 100% automatic

Breakfast And n By Dinner.



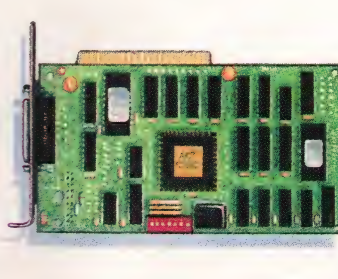
1:15 pm: Program

You load the Activator™ programming module with a 2000-gate ACT 1020 chip and hit "configure." Take a very quick coffee break while your design becomes a reality.



1:25 pm: Test

You do a complete, real-time performance check, with built-in test circuits that provide 100% observability of all on-chip functions. *Without* generating any test vectors.



4:00 pm: Production

Your pride and joy is designed, created, tested, and off to the boys in Production. And you're finished way ahead of schedule! Better think of something to do until 5:00.



6:00 pm: Dinner

Remember dinner? Normal people actually go home and eat with their families. On your way, start thinking about how Actel's logic solution can help you be brilliant tomorrow.

placement and routing. Guaranteed. So you finish fast, and never get stuck doing the most tedious part of the job by hand. And design verification is quick and easy, with on-chip Actionprobes™ that work with your logic analyzer to provide 100% observability of internal logic signals. Guaranteed.

All this is made possible by Actel's invention of the revolutionary PLICE™ antifuse programming element. Developed specifically for logic integration, PLICE antifuses and Actel's gate array architecture let you pack more functionality into much smaller spaces. No more splitting



equations across multiple PLDs. Or being short on flip flops. Or running out of connections halfway through routing.

Every Actel part is fully tested at the factory, and each antifuse is verified during programming. So you don't have to give up testability for convenience.

You can be brilliant right now with 1200- and 2000-gate devices, and 6000-gate parts are on the way.

Call 1-800-227-1817, ext. 60 today for a free demo disk and full details about the whole Actel logic solution.

It could make your whole day.



Who was the second person



Captain James H. Doolittle was the second person to break the sound barrier at Muroc Dry Lake, on October 1, 1948.

to break the sound barrier?



Someone worked every bit as hard as Chuck Yeager and came in second. The sad truth is, no matter how fast you go, getting there second isn't fast enough.

The same holds true in the marketplace.

That's why AMD concentrates on complete design solutions that cut product development time. So your product won't be obsolete before it's shipped.

Take our 32-bit RISC microprocessor, the 29K™. At 17 MIPS, it's at the heart of some of the fastest, most powerful equipment now being built.

And everything you need to get to work is here. Today. From silicon to tools for hardware and software development. From AMD or any of 40 Fusion29K™ partners.

Which makes it easy for you to go out and get your share of the profits before anyone else gets off the ground.

Take your pick. You can work hard and produce anonymous products.

Or take AMD and fly to market.

Advanced Micro Devices

For more information write "AMD and 29K" on your letterhead and mail to: AMD Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS United Kingdom.

Bruxelles (02-2) 771 91 42 • Geneva (02) 2880025 • Hannover area (0511) 73 60 85 • Hong Kong (5) 8654525
London area (0483) 740440 • Manchester area (0925) 828008 • Milano (02) 3533241 • München (089) 41 14-0
Osaka (06) 243-3250 • Paris (1) 49 75 10 10 • Seoul (02) 784-7598 • Singapore (65) 348 1188 • Stockholm (08) 733 03 50
Stuttgart (0711) 62 33 77 • Taiwan (02) 7213393 • Tokyo (03) 345-8241
Latin America, Fort Lauderdale, Florida/U.S.A. Tel: (305) 484-8600 Tlx: (510) 955-4261 amd fl
© 1989 Advanced Micro Devices, Inc. 29K and Fusion29K are trademarks of Advanced Micro Devices, Inc.



If you miss the window, the profit picture changes.

■ Well-timed market entry contributes to profit and market share. ■ Orbit Semiconductor is the manufacturing service that enables you to meet critical market windows. ■ **QUICK TURNAROUND** is guaranteed on engineering prototypes and volume production IC runs. ■ **CUSTOM** process development and **HI-REL** processes available for military, medical and industrial products. ■ State of the art MOS processes support **DIGITAL**, **MIXED ANALOG/DIGITAL**, and **CCD** designs. ■ Noncompetitive second sourcing is guaranteed since service and quality are our **ONLY** standard products. ■ Make a well-timed call to Orbit Semiconductor and find out how responsive semiconductor manufacturing can add to your profit picture. ■ Orbit Semiconductor, Inc. 1230 Bordeaux Drive. Sunnyvale, CA 94089. Twx 910-339-9307, FAX (408) 747-1263. Or call (800) 647-0222 or (408) 744-1800.



A subsidiary of Orbit Instrument Corporation.

What others promise, we guarantee.

REGIONAL REPRESENTATIVES: East Coast (609)428-6060, - Midwest (303)530-4520 - West Coast (408)241-8111, (714)253-4626, (602)996-0635, (602)293-1220, (505)888-0800.
INTERNATIONAL REPRESENTATIVES: Canada (514)481-3313 - U.K. Phone (0372) 377779, Tlx 897628 S.G. U.K.-G, Fax (0372) 376848 - Europe Phone (06031) 61076, Tlx 6031 948,
FAX (06031) 61788 - Australia Phone (8) 223 5802, Tlx UNIVAD AA89141, Fax (8) 224 0464.

MILITARY RELAYS

Devices let aircraft use higher voltages



The electronic subsystems for tomorrow's aircraft will derive their power from high-voltage dc power systems. Advanced military relays enable next-generation aircraft to use these higher dc voltages.

Margery Conner,
Regional Editor

Aircraft systems designers have long agreed that a high-voltage dc power system for aircraft would allow a significant reduction in size and weight from the current 28V dc, 115V, 3-phase, 400-Hz ac systems. They haven't been able to use a higher voltage, however, because the industry lacked devices that could switch current at the higher dc voltage. Today's military relays, however, can carry hundreds of amperes at hundreds of volts. Thanks to these recently improved relays, the next generation of military and commercial aircraft will undoubtedly have high-voltage dc power systems.

Aircraft design contracts are in the bidding stage now, and neither the government agencies nor the prime contractors will say exactly what the dc voltage standard for military aircraft will be. However, the voltage will probably be

270V dc, because many existing subsystems obtain 270V dc power by implementing a full-wave rectification of the present 3-phase, 115V ac power. You can easily make these existing subsystems compatible with next-generation aircraft by pulling out the rectification circuitry from the subsystem and using the aircraft's raw 270V dc power.

One advantage of using higher dc voltages in aircraft is that systems that operate at such voltages save on size and weight, and are therefore more power efficient. For example, 400-Hz military aircraft generators have approximately 75% power efficiency, and 270V-dc generators have 80% to 90% power efficiency.

Designers of military systems are reaping additional savings from the use of smaller-gauge wire with the lower currents that result from higher voltages, and by using smaller magnetic



Next generation aircraft like the Army's Light Helicopter Experimental (LHX) may well benefit from reduced electronic subsystem size and weight—designs made possible by the use of high-voltage dc power systems. (Artist's concept courtesy McDonnell Douglas/Bell Helicopter Textron)

TECHNOLOGY UPDATE

Military relays

cores in both power supplies and actuating motors. The newly developed, high-torque, samarium cobalt, brushless dc motors, for example, are a low-weight alternative to the hydraulic actuators currently used on aircraft.

Weight and size efficiency aren't the only advantages of high-voltage dc power. A dc generator is much quieter than a 400-Hz, 115V ac generator. Therefore, the radar signature of an airplane that has a high-voltage dc power system is much smaller.

Advanced relays for high current

Nevertheless, the military can't enjoy these benefits of high-voltage dc power systems without using more advanced relays that can carry high current at such high voltages. In the past, the three types of relays—solid state, electromechanical, and a hybrid of the two—presented crippling problems for engineers who wished to use higher voltages. Solid-state relays couldn't handle high current, and electromechanical relays had arcing problems; hybrids offered the advantages as well as the potential problems of both. Improvements in process technology have made it possible for relays to handle high current at higher voltages, but you'll have to consider each relay type carefully to decide which is most suitable for your high-current switching needs.

Of the three relay types, solid-state relays have had the most trouble handling high current. They switch current quietly because they have no mechanical contacts to cause arcing, but their junction voltage drop dissipates so much heat that at currents higher than approximately 5A, the relay's heat sinks make the relay package too large to use.

The M33C-5NS from Teledyne Solid State is one of the few mili-

tary-rated solid-state switches capable of switching current at 270V dc. This relay has a maximum continuous operating voltage of 270V dc at 1.8A with no heat sink, and it fits in a $0.8 \times 1.4 \times 0.25$ -in. package. Thus, it can dissipate 486W without a heat sink. That wattage is a lot of power for a solid-state device, but it's still not enough for many aircraft applications, which require a relay to come in a small package and yet handle hundreds of amperes. The M33C-5NS costs \$326 (50).

Unlike solid-state relays, electromechanical relays excel at carrying high currents. Because electromechanical relay contacts are metal, they have virtually no voltage drop, and therefore they require no heat sinks. One disadvantage of electromechanical relays is that they arc across their contacts upon being opened or closed, unlike solid-state relays. The next generation of military aircraft will spend much of its time at altitudes higher than 50,000 ft. The low-pressure atmosphere at these high altitudes causes acute arcing problems.

Hybrid relays consist of an electromechanical relay shunted with a solid-state relay, in an attempt to

combine the arcless operation of solid-state devices with the low power dissipation of electromechanical relays. In a traditional hybrid design, the power semiconductor performs all the switching, carrying the full current for only a few milliseconds before the main contact—the electromechanical relay—switches in. Therefore, the solid-state device makes and breaks the circuit, and the electromagnetic contacts carry steady-state current. The presence of the solid-state relay not only quenches the electromechanical arc, but also eliminates bounce erosion on the metal contacts.

Nevertheless, hybrid relays are no panacea for all switching problems. At currents higher than approximately 100A, the energy that the semiconductor must absorb to quench the arc may require heat sinks that would be too large to use.

RPCs provide intelligence

Eaton's Aerospace and Commercial Controls Division has developed a purely electromechanical switch called a remote power controller (RPC). An RPC is an intelligent relay. It does more than simply switch power to a subsystem; it also

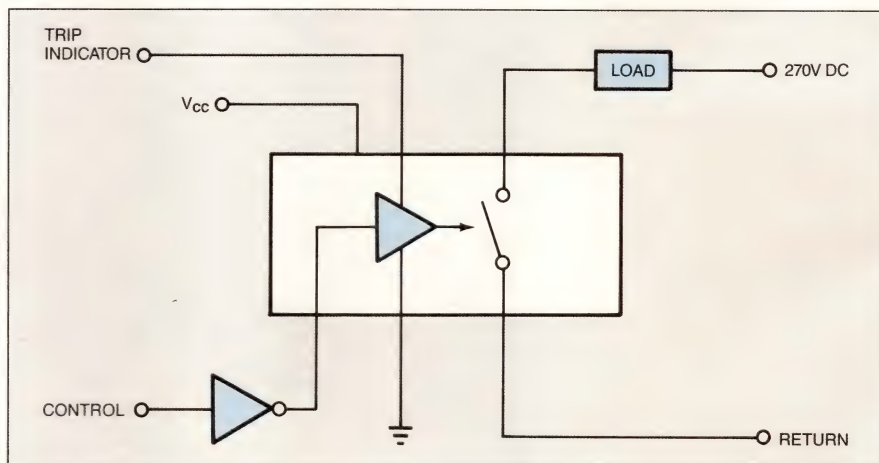


Fig 1—This simple solid-state relay, the M33C-5NS from Teledyne Solid State, doesn't qualify as an RPC because it has the absolute minimum of status information—a trip indicator. However, for many low-current applications, a trip indicator provides all the status information you'll need.

TECHNOLOGY UPDATE

provides information about its status to a system computer. Common status information for an RPC is whether the relay is on or off, and why. Not all relays in next-generation aircraft will have to supply this degree of intelligence; notice that the Teledyne solid-state relay shown in Fig 1, which will be used in next-generation aircraft, provides only one status line.

Eaton's electromechanical RPC optically isolates its control logic from its power lines, to prevent noise on the power line from falsely triggering the control logic. If the environment is extremely noisy, and you wish to further isolate the RPC, you can power the relay from a separate power source other than the one the RPC is switching.

Eaton's RPC is unique because it uses an arc-suppression chamber to extinguish arcing. It's impossible to eliminate an arc across an electromechanical relay's contacts when the circuit is broken, so the arc must be quenched one way or another.

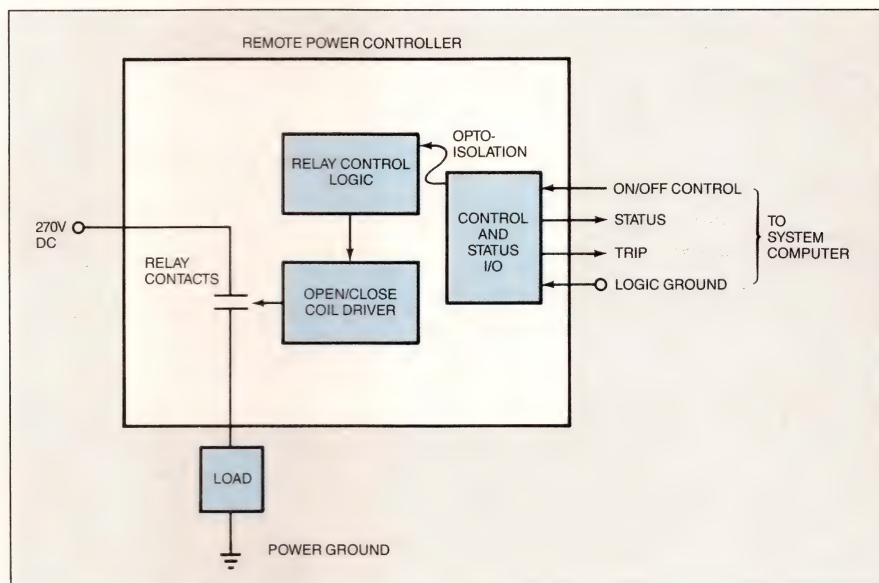


Fig 2—An RPC can supply extensive power-switch status information to the system computer. This electromechanical RPC features optoisolation of the control electronics from the power line and an arc-suppression chamber to extinguish the inevitable arc across the relay contacts. (Diagram courtesy Eaton Corp)

In a hybrid relay, the arc is fed through a semiconductor junction and dissipated as heat, but at very high currents (for example, greater than 100A), the semicon-

ductor junction can't withstand the power surge of the arc and could blow apart. Eaton's electromechanical relay drives the arc off the relay's contacts to the arc-suppres-

"No military solid-state-relay market exists"

The best indicator of a viable market in electronic components is when several companies offer a catalog of standard parts, says Harvey Laner, vice president of marketing for Teledyne Solid State. Laner maintains that, by offering a catalog, a manufacturer signals that it can supply standard parts, often off the shelf. Until it has standard parts, a manufacturer can't take advantage of the economies of scale and the knowledge and refinements made possible by mass producing a standard part. In addition, when a company offers standard parts, designers gain confidence that the company can deliver the parts.

The Department of Defense (DoD) has vowed to standardize the parts it procures. Nevertheless, Laner points out that the government is still paying more for custom parts due to the current lack of standardization in the military solid-state-relay marketplace.

Laner offers several reasons for this lack of standardization in military solid-state relays. First, for several years, manufacturers have marketed solid-state relays as unique power-control units that must be custom ordered for each application. Sometimes this customization is necessary, but often it is not. As a result, engineers, not seeing parts readily

available, create their own solid-state relays by taking a power FET, adding optical isolation and a logic-interfacing buffer stage, and ending up with a device that should have been available in a catalog in the first place.

Teledyne Solid State is now encouraging other manufacturers to make standard solid-state parts. Leach Relays, traditionally an RPC manufacturer, is seeking to enter the standard military-relay market by second sourcing Teledyne Solid State relays. Laner emphasizes that there can be no viable military solid-state-relay market until a good number of companies offer a catalog of standard parts.

TECHNOLOGY UPDATE

Military relays

sion chamber, where the arc is broken down and extinguished. The arc is still there, but it can't ignite anything or be detected by radar.

Eaton's RPC fits into a $5 \times 4.5 \times 4.5$ -in. package. It's much bulkier than a solid-state device, but it doesn't require heat sinking. Each RPC costs approximately \$2000, depending on the control circuitry.

A little-known alternative

Solid state, electromechanical, and hybrid relays are the traditional relay types with which everyone is familiar. But you should consider another, less well-known relay for your high-voltage, high-current switching needs: a type of electromechanical relay called a vacuum relay.

Vacuum relays are electromechanical relays whose contacts are enclosed in a vacuum. Because a vacuum relay has no gas molecules to ionize, no spark can jump across its metal contacts. Kilovac's KPC2 series of RPCs handles 15A without arcing or requiring heat sinks.

The size of Kilovac's vacuum relay is $3.25 \times 1.5 \times 2.2$ in. The metal contactors are the only portion of the relay enclosed in a vacuum. Because the contactor gap is enclosed in a vacuum, the gap size is smaller than it would be under normal atmospheric conditions, and the relay's actuating coil shrinks to correspond to the smaller gap size (Fig 3). The relays cost approximately \$1200 each. The basic contactor (AP 44A), which supplies no status information, costs \$275.

These advanced relays are not only helping aircraft systems designers to attain their longtime goal of using higher dc voltages, but will benefit designers in the commercial sector as well. For example, the electronic subsystems of automobiles are also requiring ever-in-

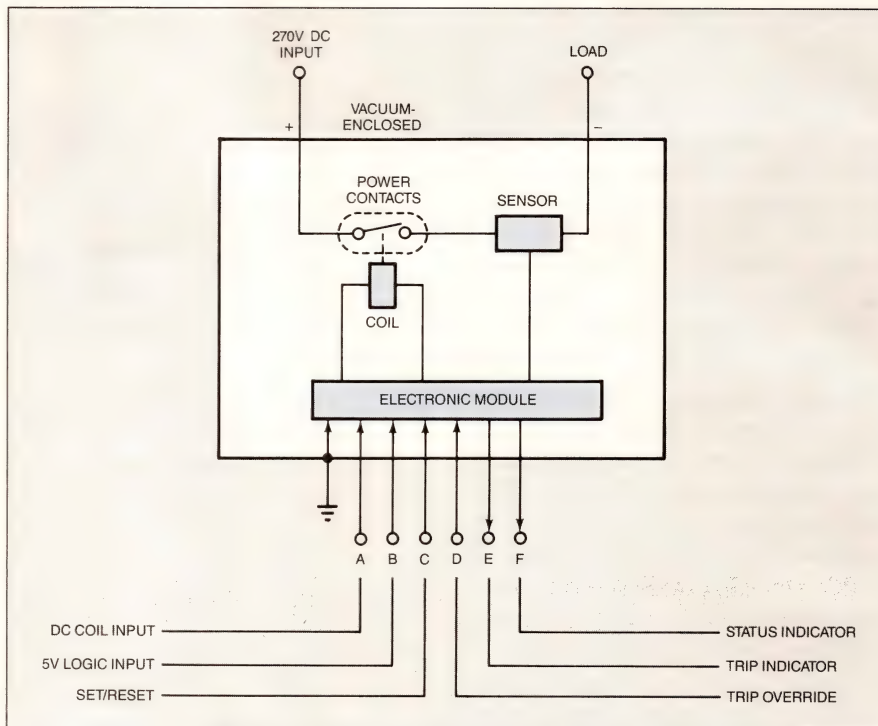


Fig 3—Only the relay contacts are enclosed in a vacuum in the KPC2 RPC. Internal to the unit, the sensor monitors the open/closed status of the relay contacts and the status of the load, and it reports the status to the electronic module. Status Indicator reports the status of the power contacts, and Trip Indicator shows if the unit's maximum current has been exceeded. Unless the system computer activates Trip Override, the relay contacts open. Set/Reset clears the Trip Indicator signal. (Diagram courtesy Kilovac)

For more information . . .

For more information on the military relays discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Eaton Corp
Aerospace and Commercial Controls Div
4201 N 27th St
Milwaukee, WI 53216
(414) 449-6413
FAX 414-449-6221
Circle No 711

Kilovac Corp
Box 4422
Santa Barbara, CA 93140
(805) 684-4560
FAX 805-684-9679
Circle No 712

Leach Corp
6900 Orangethorpe Ave
Buena Park, CA 90620
(714) 739-0770
FAX 714-739-1713
Circle No 713

Teledyne Solid State
12525 Daphne Ave
Hawthorne, CA 90250
(213) 777-0077
FAX 213-779-9161
Circle No 714

VOTE . . .

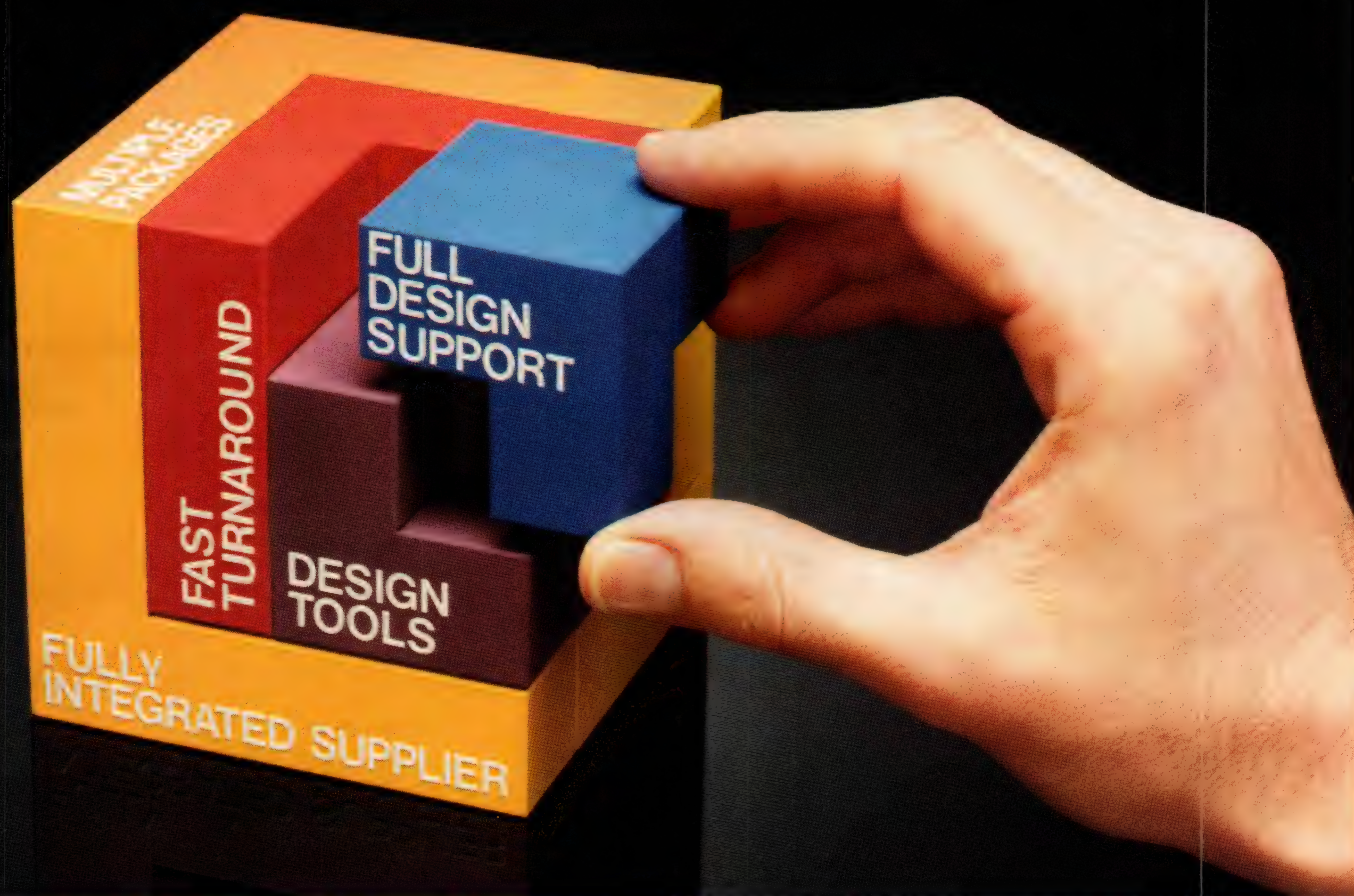
Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 515

Medium Interest 516

Low Interest 517

The Analog ASIC Solution



All the pieces—from Raytheon, your development partner:

Raytheon's RLA Linear Array Family of user-configurable macrocell arrays—and full design support. (RLA 40, 80, 120, and 160)

□ **Configurable macrocells:** 4, 8, 12 or 15 gain blocks that can be configured into a variety of analog functions to achieve your system's needs.

□ **Design support:** Raytheon offers a comprehensive design kit containing applications and design documentation, 200X plots, a printed circuit board, and 23 macrocell kit parts.

Software includes SPICE¹ model data files that can run on PCs and various workstations.

Application engineers provide personalized service and full support from design conception through product delivery. Take advantage of Raytheon's extensive experience in custom and semicustom products.

□ **And more:** Choose from a wide variety of packages including plastic and ceramic DIPs, SOICs, PLCCs, and LCCs in commercial, industrial and military temperature ranges.

Analog ASICs need not be a puzzle. Not with Raytheon's RLA Family. And the support we provide with more than 15 years' experience as a supplier of high-volume commercial custom and semicustom devices.

Call us for complete RLA program information and details on the RLA Macrocell Array Design Kit.

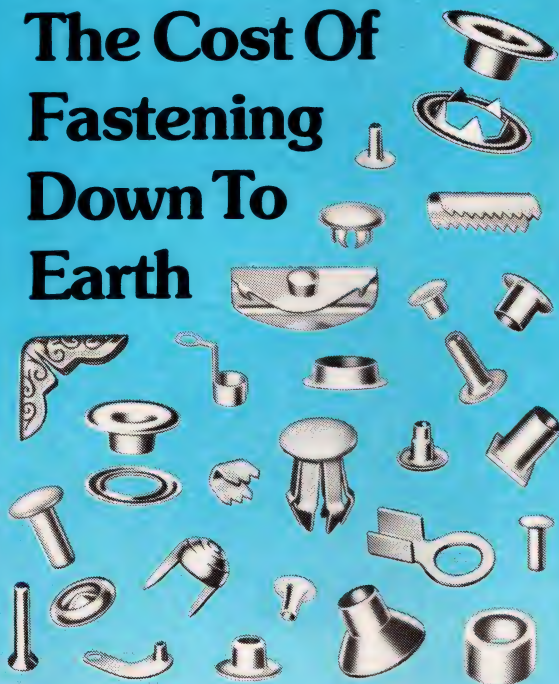
Raytheon Company
Semiconductor Division
350 Ellis Street
Mountain View, CA 94039-7016
(415) 966-7716

Raytheon

Where quality starts with fundamentals.

¹ SPICE developed by University of California

Stimpson Brings The Cost Of Fastening Down To Earth



That's the reason so many designers, buyers and production people responsible for holding down costs while maintaining quality have turned to Stimpson Fasteners and Fastening Machines.

Send a sample of your product, assembled or not. Our Assembly Service experts will analyze and assemble it with the right size, style and finish eyelet or other fastener and recommend the fastening machine best suited to your application... with substantial savings, just as they've done for years, for so many others. No charge of course.

Send today for your free copy of our latest Designer's Catalog. Illustrating over 1,000 Standard Fasteners and Stampings, plus a full line of automatic attaching machines.



900 SYLVAN AVE. BAYPORT, NY 11705-1097
(516) 472-2000

CIRCLE NO 43

UPDATE

Military relays

creasing power. Designers of automobiles want to take advantage of the size and weight efficiencies offered by higher voltages. Consequently, within the next five years, you can expect to see a higher dc power system used in cars. Other commercial industries will also be demanding smaller, more lightweight switching controllers that can handle these higher voltages.

EDN

Acknowledgement

The author wishes to thank Stan Schup, engineering group specialist with General Dynamics, for his help in researching this article.

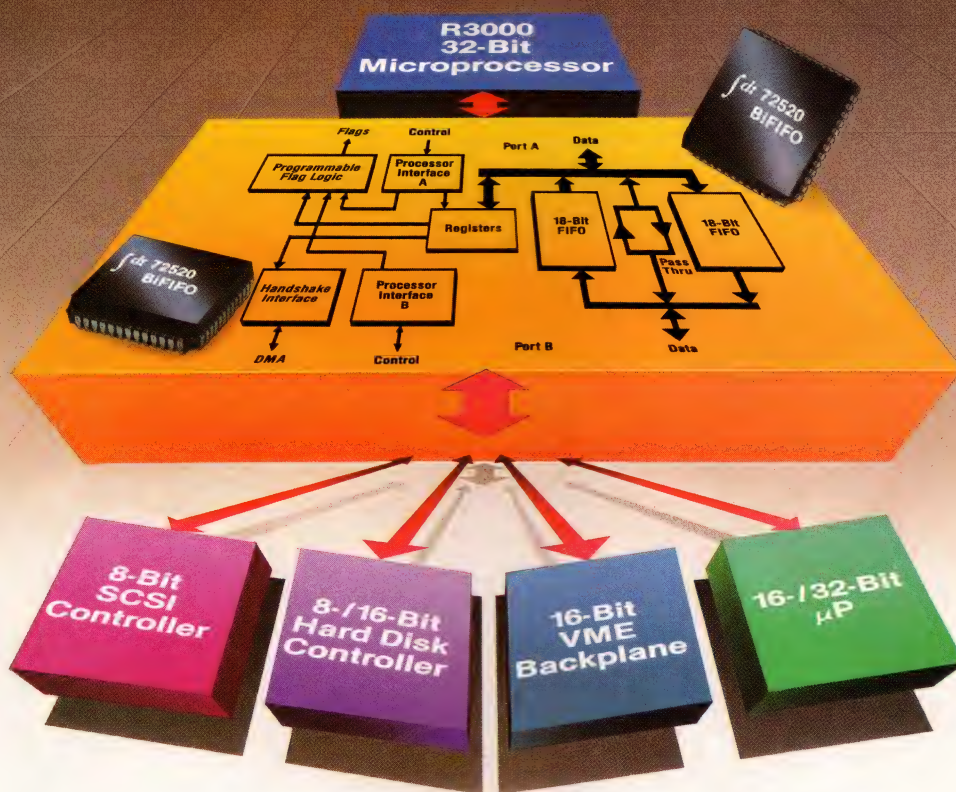
References

1. AS 1831, "Electrical power, high voltage and direct current, aircraft, characteristics and utilization of." Report published by the Society of Automotive Engineers, 1987.
2. Theisen, Peter J, Slobodan Krstic, and CG Chen, "270V dc hybrid switch," IEEE Transactions on Components, Hybrids and Manufacturing Technology, Volume CHMT-9, No.1, March 1986.
3. Jabaghourian, Harry, "Vacuum remote power controllers for high current, HVDC, aerospace power distribution and load control applications." Presented at the fourth SAE Aerospace Electrical Interconnect System Conference, San Diego, CA, Oct 14, 1987.

Article Interest Quotient
(Circle One)

High 515 Medium 516 Low 517

The μ P-to-Peripheral Connection



Introducing IDT's BiFIFOs

BiFIFOs bus match efficiently

Applications where a high-performance 32-bit RISC processor must talk to 8- or 16-bit peripheral controllers need IDT's new BiFIFO to minimize system chip count. IDT's bus matching bidirectional FIFOs make the ideal zero wait state connection between state-of-the-art processors and peripherals.

The BiFIFO integrates 18-bit to 9-bit bus matching logic and two full FIFO memories in one chip. Now for the first time a single chip can handle simultaneous communication in both directions. And at 35ns the BiFIFO meets your processor performance needs.

Programmable configuration interface

Our BiFIFO has a microprocessor interface that gives you control over the BiFIFO's "personality." Ten registers configure features such as programmable flag offset, flag pin

assignment, DMA handshake, direct pass-through, and parity.

Flag offset can be programmed to any depth, giving you power over block transfer size and critical interrupts. The BiFIFO's DMA logic manages data block transfers, freeing your microprocessor for other crucial tasks. The pass-through path makes direct processor-to-peripheral command and status communication possible, eliminating external registers and reducing your board size.

Seamless interface for multiprocessing

Making two processors talk is not easy. But IDT's parallel BiFIFO makes the interface seamless, just like its bus matching brother. Multiprocessor arbitration is performed by the BiFIFO, simplifying your overall design. Since both of IDT's new BiFIFOs have the same architecture, whether you are using bus matching or parallel processing, we have the solution for you.

You can count on us

We know what you need. Call our Marketing Hotline at (408) 492-8675 to find out more about IDT's BiFIFOs. Or call (408) 492-8225 for a free copy of our 1989 Data Book Supplement with information on IDT's full range of high-performance system building blocks including RISC processors, SRAMs, multi-port and FIFO memories, standard and complex logic, and RISC subsystems and modules.

IDT, P.O. Box 58015, 3236 Scott Blvd., Santa Clara, CA 95052-8015, FAX 408-492-8674.

When cost-effective performance counts



**Integrated
Device Technology**

MILITARY IN



INTRODUCING VAAST-INTELLIGENCE ASICs FROM VLSI TECHNOLOGY.

The reason twenty-five of the top thirty* defense contractors enlist VLSI Technology when they need memories, logic, or ASICs is no military secret.

Our CMOS is faster than an F-15.

We back every one of our ASICs with

fully characterized military libraries.

Our tools support topdown design with system partitioning, logic synthesis, and such retargetable design-to-technology alternatives as GaAs, 1-micron and rad hard CMOS.

And thanks to our VAAS^TIntelligence™ ASICs and VHDL interface, your system will be easy to test and improve throughout the program lifecycle.

*Based on *Defense Electronics*, December 1987, listing. © 1989 VLSI Technology, Inc.
™ VAAS^TIntelligence is a trademark of VLSI Technology, Inc.

TELLIGENCE



WE'RE IN THIS FOR THE DURATION.

We have a Class 1 sub-micron facility in San Antonio, Texas.

Our Arizona site builds mil-spec ICs and is one of the first ASIC beta sites chosen for the United States Government's QML Program.

And that's not all. Our military process

is backed up by compatible second sources.

Call one of our seasoned veterans at 1-800-872-6753 and ask for our Government Products brochure. Or write to us at 1109 McKay Dr., MS32, San Jose, CA 95131.

Once you use us, we know you'll want to re-enlist.



VLSI TECHNOLOGY, INC.

TEXAS INSTRUMENTS REPORTS ON

BOTH SIDES OF

IN THE ERA OF MEGACHIP™ TECHNOLOGIES

THE
UP
SIDE.

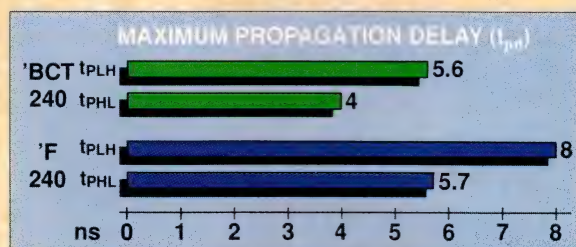
THE
DOWN
SIDE.



BiCMOS LOGIC

TI's BiCMOS logic gives you drive and speed up to par with advanced bipolar devices.

The chart says it all. Switching speeds of our BiCMOS family, designed specifically for bus interface implementations, are



TI's speed advantage: In a one-on-one comparison, a TI '74BCT240 BiCMOS octal bus driver proves to be much faster than a standard advanced bipolar equivalent.

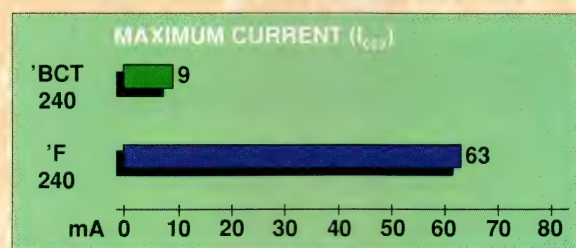
comparable to advanced bipolar counterparts. Drive currents meet the requirements of today's industry-standard buses: 48/64 mA commercial, 24/48 mA military.

For example, our BCT2XXX memory drivers are two times faster than the competition's memory drivers. They not only solve the undershoot/overshoot problems associated with driving DRAM memories but also conserve real estate by incorporating a 25-ohm series damping resistor on chip. With this speedy family comes a bonus, reduced switching noise. Case in point: An independent analysis* found our SN74BCT240 octal bus driver to have the fastest propagation delay (3.8-ns t_{PHL}) with the highest signal integrity (0.8-V simultaneous switching noise).

But there's another impressive side to the BiCMOS family story. Read on.

TI's BiCMOS logic cuts power consumption down to CMOS levels.

As you've gathered by now, our BiCMOS logic combines high-speed bipolar with low-power CMOS. Disabled currents can



TI's power advantage: Here again, the BiCMOS driver wins over the advanced bipolar counterpart, exhibiting far less power dissipation.

be reduced as much as 95% (see chart) while active currents are cut as much as 50% compared to advanced bipolar equivalents.

As a matter of fact, total system power savings can be more than 25%.

Our BiCMOS family now numbers more than 40 members and will top 90. All

members are compatible with advanced bipolar sockets, allowing easy plug-in upgrades.

BiCMOS technology is also enabling us to solve other problems that crop up in bus interface design. For example, the family will soon include a series of SCOPE™ Octals to provide system-embedded test capability. Also, the forthcoming BCT25XXX IWS line drivers will assure incident wave switching (IWS) down to 25 ohms.

For free samples of our BiCMOS logic family: In Europe call 44-234-223000, fax 44-234-223459, or write Customer Response Centre, MS 09, Texas Instruments Limited, Manton Lane, Bedford MK41 7PA, England. In Asia call 852-3-7351223, fax 852-3-7354954, or write Texas Instruments Hong Kong Limited, Market Communications Manager, 8/F World Shipping Centre, 7 Canton Road, Tsimshatsui, Hong Kong.

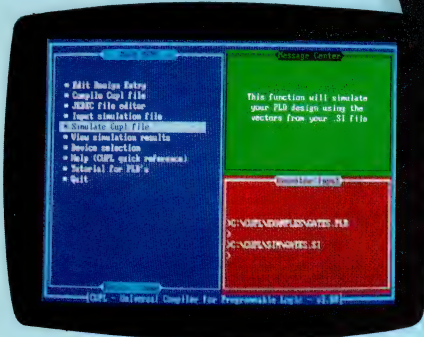
* David Shear, "EDN's advanced CMOS logic ground-bounce tests," EDN, Special Report, March 2, 1989.

™ MegaChip and SCOPE (System Controllability and Observability Partitioning Environment) are trademarks of Texas Instruments Incorporated.



THE TOP PLD COMPILER.

CUPL™ was introduced in 1983 as the world's first universal device independent PLD language. It was developed with the foresight that someday PLDs will approach the gate densities of Gate Arrays. CUPL's™ superiority is evident in Release 3.0, which features the largest PLDs on the market, with room for future expansion. CUPL™ provides you with the best device support program on the market.



- ▲ Menu driven or command line entry software.

Available Platforms

IBM-PC™
MS-DOS™
UNIX™

VAX-VMS™
Apollo™
SUN™

**LOGICAL
DEVICES, INC.**

800-331-7766

1201 NW 65th Place, Fort Lauderdale, Florida 33309
(305) 491-7404 Toll Free 800-331-7766 Telex 383142 Fax (305) 491-6956

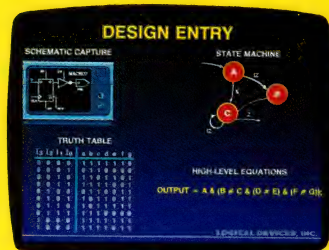
VAX and VMS are trademarks of Digital Equipment Corporation
UNIX is a trademark of AT & T Technologies, Inc.
PALASM is a registered trademark of Monolithic Memories, Inc.

IBM-PC is a registered trademark of International Business Machines, Inc.
MS-DOS is a registered trademark of Microsoft Corporation

CIRCLE NO 47

CUPL™ 3.0

- ▲ Includes more device libraries than any other software package.
- ▲ Supports large device models such as the Altera EP1800, Atmel ATV2500, and Xilinx LCA.
- ▲ Includes PALASM™ to CUPL™ converter.
- ▲ State Machine design compiles over 1000 states in less than 60 seconds.
- ▲ Works with any device programmer.
- ▲ Includes user definable syntax and logic structure macro capability.
- ▲ Available on multiple hardware platforms in a single or multi-user environment.



- ▲ Allows design entry with popular schematic capture packages from OrCAD, P-CAD, Wintek or Omaton.



- ▲ Includes a five level minimizer and powerful function simulator with waveform simulation output.
- ▲ Automatic test vector generation, fault grading option (TESTPLA™).

TRADE IN any PLD compiler and receive a trade-in discount. (Program honored through all participating distributors.)

ECL GATE ARRAYS AND PLDs

ECL ICs play a role in high-speed computers



ECL gate arrays currently offer densities with CMOS complexities, and PLDs exist for "glueing" systems together.

John Gallant,
Associate Editor

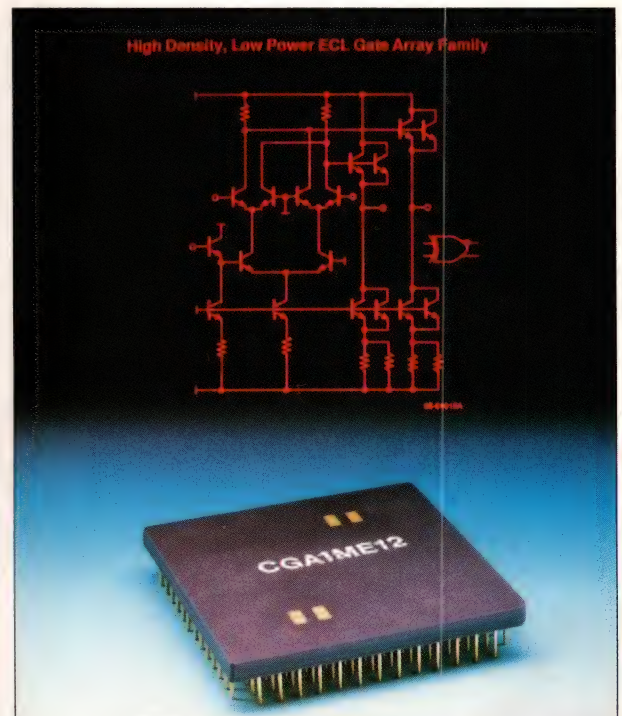
The never-ending quest for high performance in workstations, mainframes, ATE, telecommunications, and military systems mandates the use of high-speed, semicustom ASICs. System designers realize that LSI and MSI (medium-scale integration) offerings in the various logic families are inadequate for their needs. To fill this void CMOS, bipolar ECL, and GaAs vendors offer a variety of gate arrays and PLDs. Gate arrays satisfy applications requiring medium- to large-scale complexities, whereas PLDs are ideal for less complex designs. Each technology, however, has its pros and cons.

Current ECL gate arrays provide large-scale integration comparable to that of CMOS arrays, speed-for-power tradeoffs for thermal management, unloaded gate propagation delays of 300 psec or less, and cost and complexity advantages over their GaAs counterparts. Some recent interest in ECL gate arrays comes from Bipolar Technologies, which has produced an ECL version of Sun's SPARC processor, and Motorola, which has collaborated with Data General to transfer the 88000 reduced-instruction-set computer (RISC) CPU into ECL technology.

Even though BiCMOS and GaAs developments threaten ECL's overall market share, ECL does have a niche marketplace. Although bipolar

ECL is synonymous with high speed, it is also synonymous with high power consumption. For this reason, a system designer must consider reliability, packaging, thermal management, and cost when evaluating the feasibility of an ECL design. The prudent designer only opts to use ECL over CMOS in applications requiring ECL's speed advantage. Because current CMOS gate arrays can reach into the 200-MHz-and-beyond range, an ECL gate array only becomes a viable option when an application requires frequency operation over 100 MHz.

ECL gate arrays must also compete



ECL gate arrays come in a variety of densities and speed options. This Raytheon product specifies 4584 equivalent gates, has a 1.2-GHz D flip-flop toggle frequency, and a 1280-bit RAM cell.

TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

with GaAs gate arrays, which have made real inroads into the high-performance marketplace (Ref 1). By connecting enhancement- and depletion-mode (E/D) GaAs devices in a direct-coupled FET-logic configuration, GaAs products have flip-flop toggle rates greater than 1.5 GHz, and dissipate 0.2 to 0.4 mW per gate. A similar high-power ECL offering generally toggles less than 1.5 GHz, and dissipates from 1 to 2 mW per gate. Low-power versions dissipate from 0.5 to 1 mW per gate, but have lower toggle rates. However, current GaAs gate arrays are more expensive than ECL arrays for equivalent complexities. Although GaAs gate-array prices are rapidly decreasing, an ECL ASIC remains a cost-effective

option for circuits operating below 1 GHz.

ECL manufacturers currently produce gate arrays with equivalent-gate densities greater than 10,000 gates per chip. For example, Advanced MicroCircuits Corp's (AMCC) Q20000 series and Siemens' SH100E series have family members with as many as 16,000 equivalent gates, and NEC recently introduced the μ PB3000 family, which has as many as 35,000 equivalent gates. In addition, AT&T is about to introduce the BEST-I family, which will have as many as 20,000 equivalent gates, and Motorola plans to make its MCA-4 Series, a 50,000-equivalent-gate array, available in the first quarter of 1990. These large-complexity ar-

rays minimize the number of off-chip interfaces, which can negate ECL's speed advantage. (Table 1 offers a comparison of various ECL gate arrays.)

There is room for confusion when counting the number of equivalent gates for an ECL gate array, however. Gate counting is not as straightforward in ECL as it is in the other logic families. For example, CMOS gate arrays use the 2-input NAND gate as the basic unit for counting equivalent gates. Because the familiar 2-input CMOS NAND-gate topology requires four transistors, you merely have to count the number of transistors in the array and divide by 4 to arrive at an equivalent-gate count for the array.

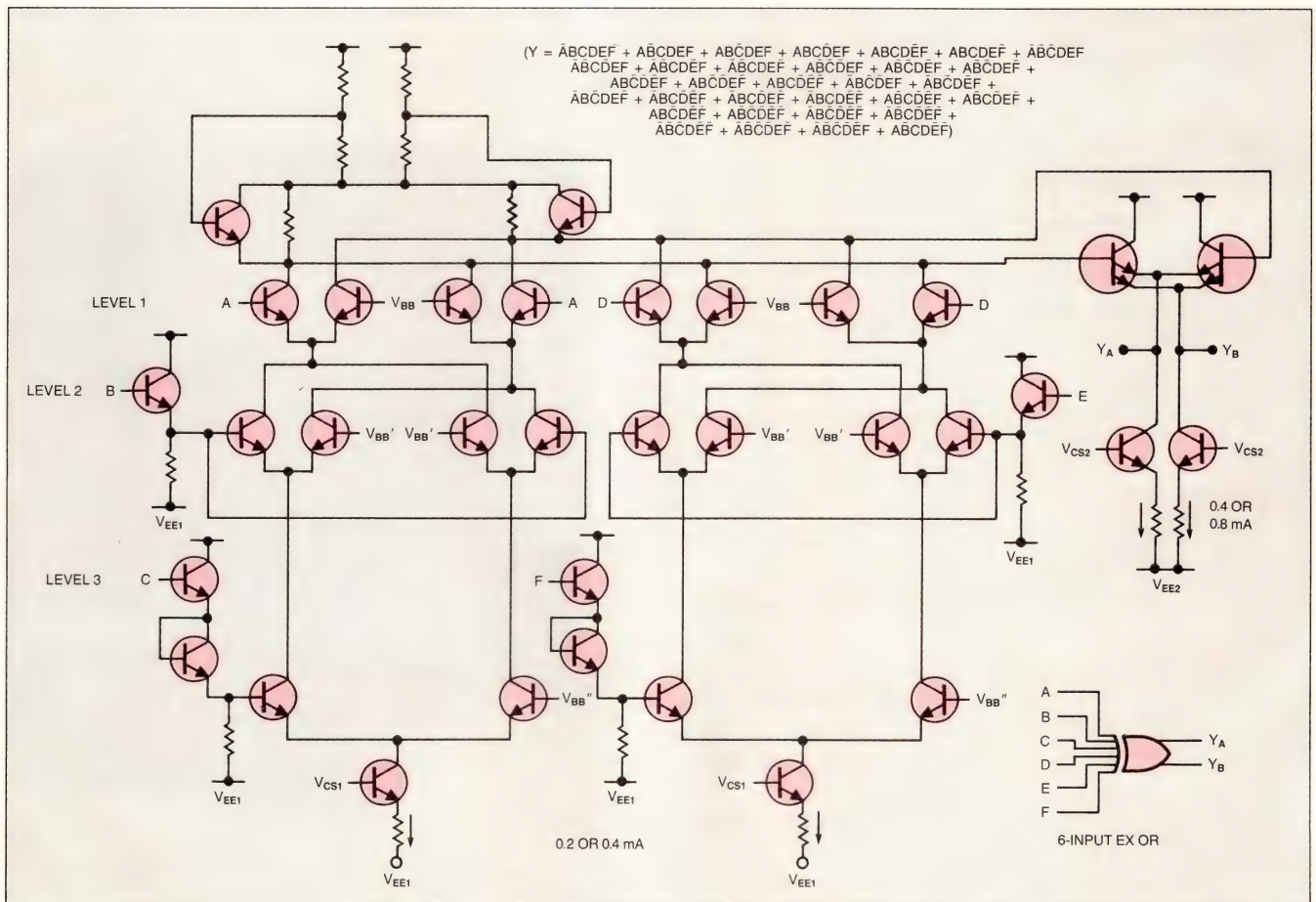


Fig 1—A schematic of a 6-input exclusive OR gate illustrates the gate economy that 3-level series gating provides. This Motorola circuit uses three bias generators, V_{BB} , $V_{BB'}$, and $V_{BB''}$ as references for three gates operating from a single current switch.

TECHNOLOGY UPDATE

However, the current-mode-logic (CML) topology for ECL gives you a wide range of flexibility when you are configuring gates. Many vendors include three temperature-

compensated, bias-voltage generators in the array, which can be used as reference voltages in a 3-level totem-pole arrangement known as series gating. The series-gate con-

figuration operates from a single current source. An example of a 6-input-exclusive OR gate using 3-level ECL gating is shown in Fig 1. To implement this function with

TABLE 1—ECL GATE-ARRAY COMPARISONS

COMPANY	PRODUCT NAME	MAXIMUM NUMBER OF EQUIVALENT GATES	MAXIMUM NUMBER OF I/O CELLS	UNLOADED GATE-PROPAGATION DELAY (μ SEC)	CHIP-POWER DISSIPATION (MAX)	D FLIP-FLOP TOGGLE-RATE (MAXIMUM) (GHz)	MAXIMUM NUMBER INTERNAL CELLS	GATE-EQUIVALENCY BASIS	COMPONENTS PER CELL	PACKAGE TYPES	COST	COMMENTS
AMCC	Q20000	16,000	256	120 140 190	16W	1.2	4274	D FLIP-FLOP W/RESET = 11 GATES = 3 CELLS	17 TRANSISTORS 17 RESISTORS	301PGA	\$0.05-\$0.07 PER GATE	MILITARY VERSION AVAILABLE, 3 METAL LAYERS TTL I/O
FUJITSU	H SERIES	9856	300	220 100	13W	1.0	1792	1 FULL ADDER = 11 GATES = 2 CELLS	16 TRANSISTORS 16 RESISTORS	208 PGA 260 FLAT PACK	\$447 (1000) \$461 (1000)	3 METAL LAYERS
	ET SERIES	6160	120	220	10W	0.80	1120	1 FULL ADDER = 11 GATES = 2 CELLS	16 TRANSISTORS 16 RESISTORS	149 PGA 164 FLAT PACK	\$168 (1000) \$177 (1000)	
	ET-M SERIES	3960	120	220	10W	0.80	720	1 FULL ADDER = 11 GATES = 2 CELLS	16 TRANSISTORS 16 RESISTORS	149 PGA	\$217 (1k)	SERIES CONTAINS ARRAYS WITH RAM CELLS, 3 METAL LAYERS
	E128H	128	16	75	3W	4.0	32	D FLIP-FLOP = 4 GATES = 1 CELL		24 FLAT PACK	\$330 (1000)	
MOTOROLA	MCA-3 SERIES	10,000+	256	120 300	6W	1.2	1656	MIXTURE OF D FLIP-FLOPS, OUTPUT LATCHES, AND INPUT ORS = 11,160 GATES	19 TRANSISTORS 19 RESISTORS	235PGA 289PGA 360TAB	\$600 (100)	3 METAL LAYERS
	MCA-4 SERIES	50,000+	400	100 140 240	25W AND HIGHER	1.2	14,784	3.5 GATES = 1 CELL	19 TRANSISTORS 19 RESISTORS	550TAB	\$1400 (100)	DESIGN-IN 1ST HALF OF 1990, 4 METAL LAYERS, ON-CHIP RAMCELL
NEC	ECL-4A SERIES	35,656	236	90 270	23.5W	1.4	3225	1 FULL ADDER = 11 GATES = 1 CELL		208PGA 280PGA 208QFP 280QFP	\approx \$750 (1000) \approx \$890 (1000)	TTC I/O, 3 METAL LAYERS
	ECL-3B	11800	172	90	15W	0.3	1600	1 FULL ADDER = 11 GATES = 1 CELL		132PGA 208PGA	\approx \$270 (1000)	TTL I/O, 2-LEVEL GATING ONLY, 3 METAL LAYERS
RAYTHEON	70E18	12,800	176	300	5W	1.2	7696 MAPS	4 TO 1 MUX = 8 GATES = 5 MAPS	6 TRANSISTORS 6 RESISTORS PER MAP	232PGA	\$460 (100)	TTL I/O, 2 METAL LAYERS. MILITARY VERSION AVAILABLE
	40E12	7,752	120	300	3.5W	1.2	4620 MAPS	4 TO 1 MUX = 8 GATES = 5 MAPS	6 TRANSISTORS 6 RESISTORS PER MAP	149PGA	\$220 (100)	TTL I/O, 2 METAL LAYERS. MILITARY VERSION AVAILABLE
SIEMENS	SH100E SERIES	10,000	256	90	25W	1.5	2604	1 FULL ADDER = 11 GATES = 3 CELLS	10 TRANSISTORS 12 RESISTORS	319PGA 68LCC	\$750 (100)	FAMILY CAN MIX ECL & CML LOGIC 3 METAL LAYERS, TTL I/O. MILITARY VERSION AVAILABLE
SONY	E3G200	200	34	150	1.7W	2.5	70	3 GATES = 1 CELL	14 TRANSISTORS 15 RESISTORS	24MFP 32MFP	\$50 (1000)	2 METAL LAYERS 100 KH LEVELS ONLY
	E3G70	70	48	>100	1.7W	3.5	70	3 GATES = 1 CELL	14 TRANSISTORS 15 RESISTORS	24MFP 32MFP	\$50 (1000)	2 METAL LAYERS 100 KH LEVELS ONLY

TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

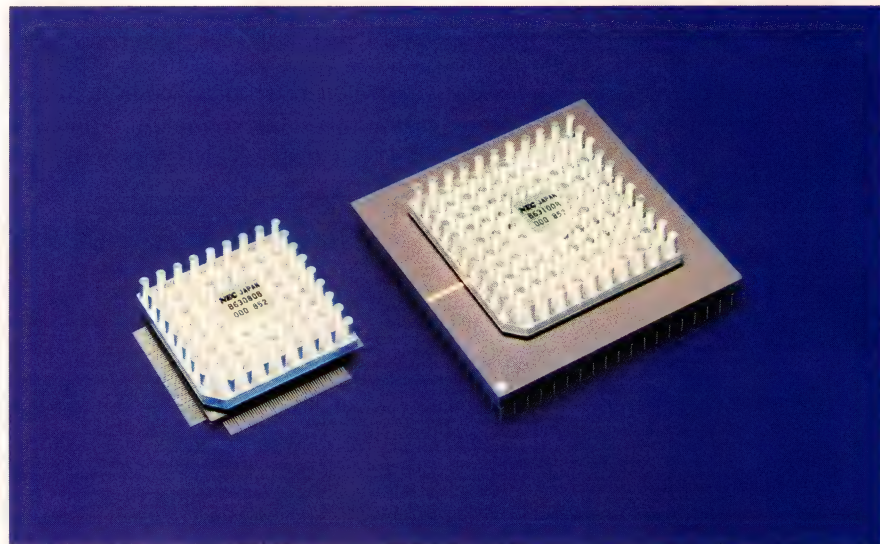
CMOS-equivalent gates would require 32, 6-input NAND gates and one 32-input OR gate.

In order to use 3-level series gating, you must provide a -5.2V supply to the chip. The large supply voltage provides an adequate margin for stacking the three reference generators, but requires either 10K or 10KH ECL-compatible voltage levels at the I/O ports. If you use a -4.5V supply, which makes the I/O ports compatible with 100K ECL voltage levels, you can only use 2 levels of series gating, thereby limiting the complexity of functions that you can design with a single current source.

Because of these anomalies, ECL gate-array vendors refer to their products as a sea of cells, rather than use the sea-of-gates terminology that applies to CMOS arrays. A cell consists of a number of transistors (typically 15 to 20) and resistors that can be configured into definable logic blocks by using macros from a cell library. The ECL array generally has an internal architecture consisting of columns of rows containing multiple cells. The bias-voltage generators are located at the end of each row. In addition, the ECL array has a number of I/O cells located around the chip's periphery.

Gate counting tests your sanity

The ECL gate-array architecture contributes to the confusion when counting the number of equivalent gates. To arrive at a gates-per-cell number, vendors implement macros, such as a full adder or a D-type flip-flop, in one or more cells and count the number of logic gates implemented in a cell. This number is then multiplied by the number of cells in the array to arrive at an equivalent-gate count. The number of equivalent gates is not the same for each macro, however. For example, NEC calculates an equivalent-gate figure of 35,656 gates for



Current ECL gate arrays offer large-scale integration densities comparable to their CMOS counterparts. NEC's ECL-4A family has a member that exceeds 35,000 gates when the cells are fully populated as full adders.

its ECL-4A array when you arrange each cell as a full adder. The same device has an equivalent-gate count of 10,000 gates when fully populated with 2-input NAND gates.

Furthermore, the number of equivalent gates per macro is not consistent among vendors. For example, AMCC implements a D flip-flop macro that uses 11 gates, whereas Raytheon's D flip-flop macro uses 7 gates, and Motorola's uses 9 gates. To further confuse matters, vendors often use the I/O cells for implementing macros. Because a typical application uses a variety of different macros, the equivalent-gate count for an ECL gate array is really only a figure of merit for the chip.

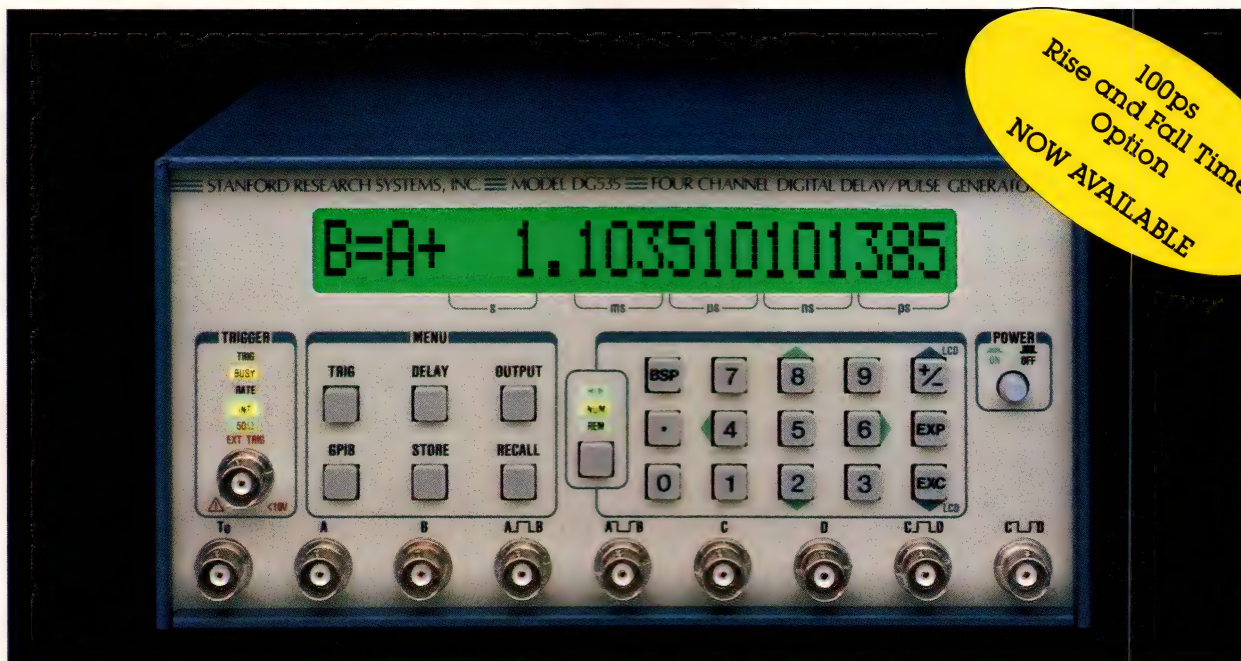
Although vendors exploit this gate-count confusion in their "one-specmanship" game, they do provide concrete information on how many cells (or fractions of cells) are required to implement a specific logic block in their macro cell library. Therefore, you can count the number of cells required to implement a logic design and use a con-

servative cell-utilization figure to size the design to a specific array.

Because current ECL gate arrays use a minimum of three metallization layers for global routing, vendors estimate the conservative cell-utilization figure of 70%. Two metal layers are usually reserved for gate interconnections; the third layer is reserved for power and ground. However, AMCC uses all three layers for gate interconnections interspersed with power and ground lines. It specifies an average 95% utilization figure for 100% routing in its Q20000 series. Plessey Semiconductor manufactures the same device and calls it the ELA80K series. Because Motorola's MCA-4 series uses four layers of metal for global routing, it boasts a utilization figure in excess of 80%.

Although multiple layers of metal in large-density ECL arrays assist you in routing gates while using CAD tools, your actual utilization figure may be limited by ECL's old bugaboo—power consumption. Although vendors offer low-and high-power versions of their arrays, virtually all of their packages require heat sinks and air flow to maintain

New Precision Pulse Generator



Four Channels, 5 ps Resolution, and GPIB Interface...Price: \$3350

TIMING IS EVERYTHING

Your critical timing problems are over. No more worries about drift, jitter, or control. The DG535 Precision Pulse Generator has four delay channels (two pulse outputs), each with a 1000 second range and 5 ps resolution. The four independent delays specify two variable-width pulse outputs. With only 50 ps jitter and accuracy down to 1 ppm (option O3), the instrument can handle the most demanding applications. The internal trigger may be programmed from 0.001 Hz to 1.000 MHz, or operated in single-shot or burst modes. Output levels are continuously adjustable or may be set to TTL, NIM, or ECL levels. High impedance or 50 Ohm loads can be driven with a slew rate of 1 V/ns. Optional rear panel outputs generate pulses to 35 volts.

EASY TO USE

The delay and output levels for each channel may be entered numerically or modified by cursor keys on the backlit LCD display. Delays may be linked together so that as one moves, the other follows. Up to nine instrument settings may be stored in nonvolatile RAM for later recall, and, of course, all of the instrument's functions may be controlled via the GPIB interface.

A GENERATION AHEAD

The DG535's precision, accuracy, range, and versatility make it the solution to all your timing needs, at a price that will meet your budget. Call us today for more information.

FEATURES AND PERFORMANCE

- Four Delay Outputs
- Two Variable-Width Outputs
- Times from 0 to 1000 sec.
- 5 ps Resolution
- 50 ps rms Jitter
- 1 ppm Accuracy (Option O3)
- Internal or External Timebase
- Internal, External, Single-Shot, or Burst Mode Triggers
- Frequency Synthesized Rate Generator
- Variable, TTL, NIM, and ECL Outputs
- Optional ± 35 Volt Outputs
- GPIB Computer Interface

FRANCE

Optilas
c.e. 1422
91019 Evry Cedex
60/77.40.63, TLX 600019

GERMANY

Spectroscopy Instruments
Carl Benz Strasse 11
D-8031 Gilling
O 8105/5011, TLX 523862

Tokyo Instruments
Koizumi Building
6-8-10 Nishikasai
Edogawa-ku, Tokyo 134
03 (686) 4711, TLX 6860831

JAPAN

Seki and Company
1-2-6 Nihonbashi Ningyocho
Chuo-ku, Tokyo 103
O3 (669) 4121, TLX J24419

UNITED KINGDOM

Lambda Photometrics
Lambda House, Batford Mill
Harpden, Herts AL5 5BZ
05827/64334, TLX 825889

Speirs Robertson
Moliver House,
Oakley Road
Bromham, Bedford
MK2302/3410, TLX 825633

Stanford Research Systems

1290 D Reamwood Avenue, Sunnyvale, CA 94089

FAX 4087449049, TEL (408) 744-9040

TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

maximum junction temperature limits when achieving a high utilization percentage. A low-power package can generally dissipate 15W using a heat sink with air flow. A high-power version might dissipate over 25W, but requires either forced-air convection or liquid-cooling techniques.

Trading speed for power

To conserve power, ECL vendors offer speed-power programming features in their arrays. Speed-power programming allows you to manage the arrays' power consumption by programming the current in the current switches. Each cell has a selection of resistors for the current switches, collector loads, and emitter followers, which let you tailor gates for low-, medium-, or high-power operation (Fig 2). To achieve optimal power management, select a speed option when you choose a macro from the cell library.

Siemens takes speed-power programming one step further by allowing you to mix ECL gates with current-mode-logic (CML) gates. The company's SH100E series, which features gate complexities from 1500 to 16,000 gates, 120-psec gate delays and 1.5-GHz D flip-flop toggle rates, lets you use ECL macros in critical paths, and use the CML macros in slower speed sections, thereby conserving power. A CML gate has the same construction as an ECL gate, but has different bias-voltage generators and no emitter followers.

All of the vendors offer CAD packages that accept data from a schematic-capture program or a simulated netlist generated on a workstation, such as those from Daisy, Mentor, or Valid. The CAD packages let you perform logic simulation (including timing verification), placement and routing, fault simulation, speed-power programming, test-program genera-

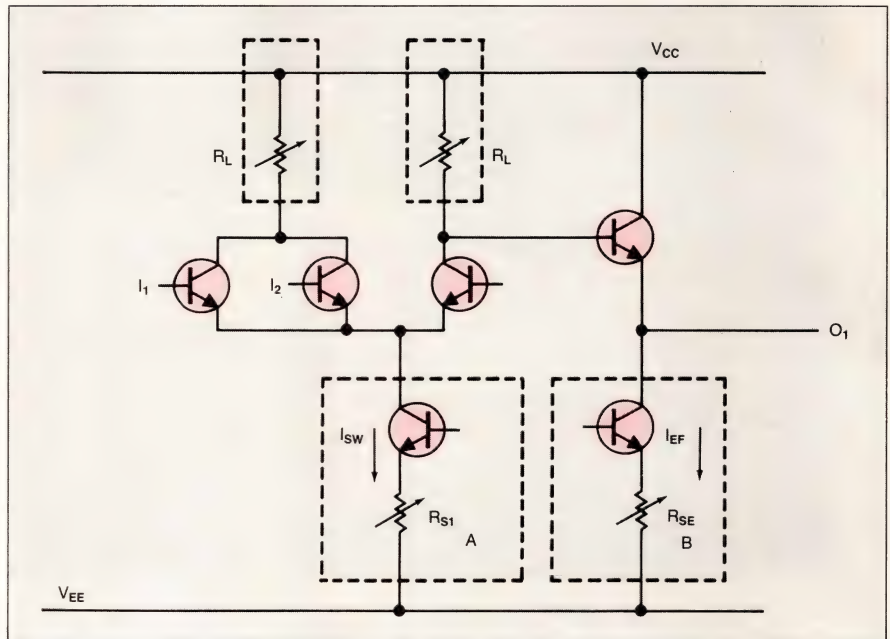


Fig 2—Speed-power programming lets you trade an ECL gate's frequency response for lower power operation. In this Siemens circuit you can independently program the current switch and the emitter follower for 0.275 mA, 0.55 mA, and 1.1 mA of current.

tion, and back annotation of actual wiring delays for design analysis. Depending on design complexity and the amount of customer involvement, NRE charges from \$40,000 to \$100,000 to develop a pattern tape for mask generation.

Some dare to be different

Although ECL gate arrays usually come in a column-by-row arrangement of internal cells surrounded by a periphery of I/O cells, some architectural differences do exist. Raytheon, for example, uses a contiguous-row approach, whereby transistors and resistors are aligned side-by-side in adjacent rows, rather than in grouped cells. The company claims that this arrangement permits a greater number of minimum-addressable programmable sites (MAPS).

MAPS consist of six resistors and six transistors. The bias-voltage generators are located at the ends of the rows. Raytheon's 70E18 and 40E12 arrays also have TTL- and CMOS-compatible I/O interfaces,

and their 1ME12 gate array contains a 1.28k-bit RAM cell.

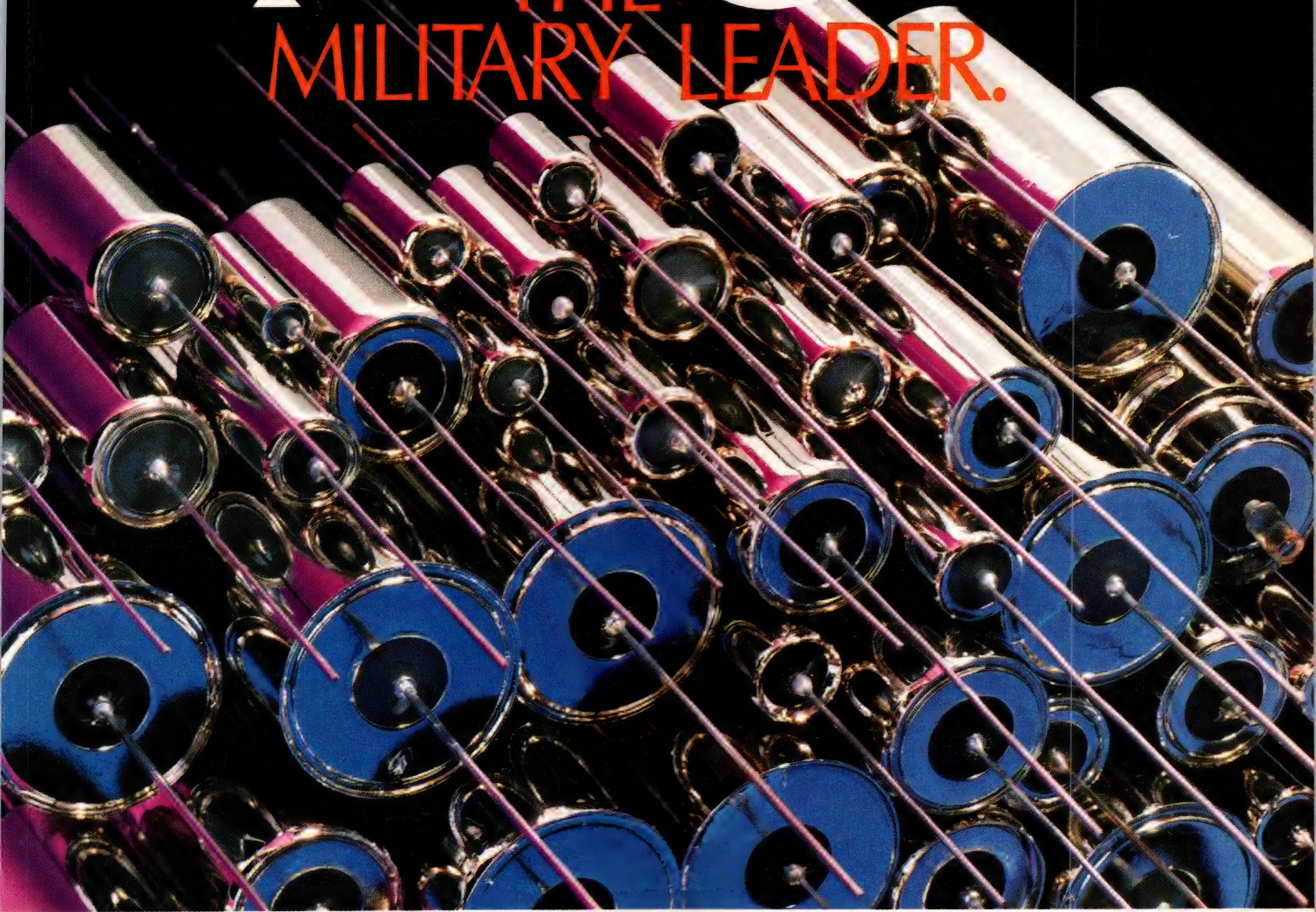
Fujitsu offers a wide assortment of ECL gate arrays with and without RAM cells. The ET2004M, ET2009M, ET3004M, and ET5005M arrays have 4.6k-, 9.2k-, 4.2k-, and 5.1k-bit RAM cells, respectively. They also have 2640, 2640, 3960, and 4928 ECL-equivalent gates, respectively. The devices' interfaces are TTL-compatible, and can be mixed with both 10KH and 100K ECL-compatible interfaces.

Besides offering on-chip RAM cells with 4k- to 180k-bit densities in its MCA-4 gate arrays, Motorola will offer mega functions in the cell library. Examples of these functions include multipliers, barrel shifters, 2-to-5-port register files, and ALU functions. The company claims that the optimized silicon will provide density, speed, and power capabilities rivaling those of full-custom designs.

AMCC products contain a circuit trick that reduces power consump-

Sprague[®]

THE MILITARY LEADER.



No one comes close to our stockpile of MIL film capacitors.

Only Sprague has film capacitors to meet so many military specifications. In fact, Sprague is the world's largest supplier of MIL-spec film capacitors.

And we got to be that way not only by offering a complete range of dielectric materials, of capacitance, tolerance, and failure levels and voltage ratings,
EDN August 17, 1989

but also by offering the reliability that comes from millions of real-time hours logged in military applications.

Sprague MIL-spec film capacitors are competitively priced and available through the nationwide network of Sprague Distributors.

Write for our new "Quick Guide to Film Capacitors."

CIRCLE NO 49

Sprague Electric Company,
Technical Literature Service,
P.O. Box 9102, Mansfield, MA
02048-9102. Or contact your
Sprague Sales Office or
Franchised Sprague Distributor.



TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

tion and reduces the skew between the rising and falling edges on an ECL output signal. Whereas conventional ECL structures use an emitter follower biased with a current source, the Q20000 series has a proprietary discharge circuit (Fig 3). The circuit supplements the emitter follower, which provides an active pullup for the load, with a capacitively coupled, pulldown transistor. When the output switches from a high state to a low state, the pulldown circuit provides a turbo discharge for the capacitive load.

Large arrays have plenty of I/O

Coupled with the high-density arrays, ECL vendors offer a wide range of packages with a large number of I/O ports. All of the arrays claiming to have equivalent-gate

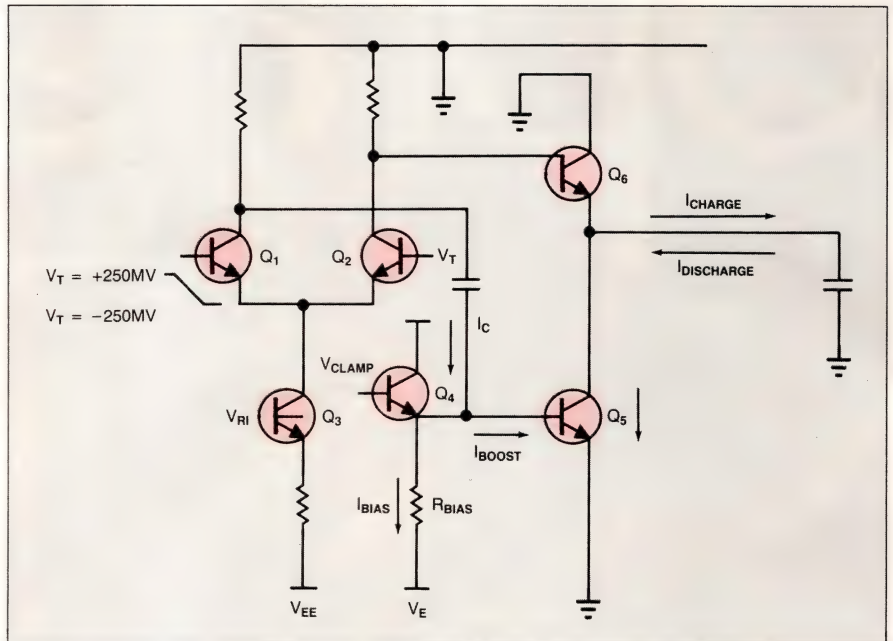
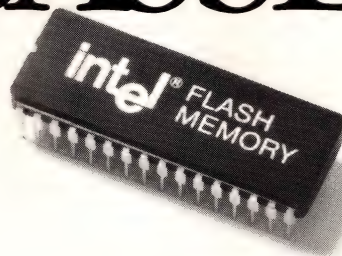


Fig 3—The capacitively coupled pull-down circuit on the output of the gates in the Q20000 array provides a turbo discharge for capacitive loads. The circuit reduces the overall power consumption and equalizes the skew in the rise and fall times.

20X LOWER UPDATE COSTS THAN EPROMS. NO DISASSEMBLY.

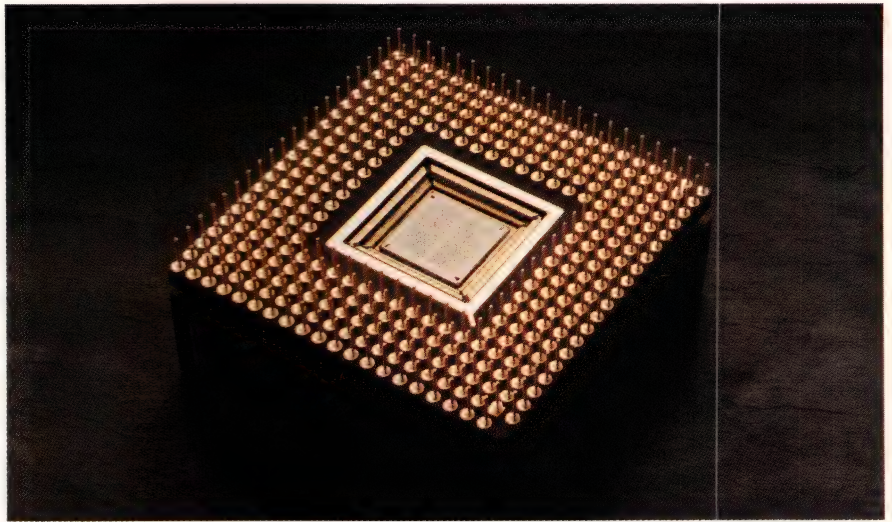


TECHNOLOGY UPDATE

densities greater than 10,000 gates come in versions that have more than 200 I/O ports. Standard packages include pin-grid arrays with pin-fin heat sinks for power dissipation. In addition, Motorola and Siemens offer their arrays on a TAB (Tape Automated Bond) package, which provides as many as 360 leads with pitches as low as 0.004 in.

But, very large density arrays with lots of I/O may not be suitable for your needs. There is no sense in using a gate array with more equivalent gates than is necessary for a particular application. In fact, lower density arrays are often faster than high-density devices because there are fewer gates simultaneously switching and, therefore, less crosstalk in the internal circuitry.

Estimating speed, however, re-

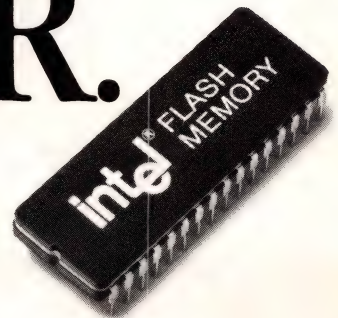


Standard ECL gate-array packages include ceramic pin-grid arrays (CPGA) with pin-fin heat sinks. Siemen's SH100E array comes in a CPGA with as many as 319 pins.

quires some caution. The rule of thumb that vendors use when specifying the speed of a gate array is the D flip-flop toggle rate. The tog-

gle rate usually is obtained by connecting the Q output directly to the D input on an internal flip-flop. If your circuit requires a gate in the

100X THE SPEED OF DISK/DRAM. NO MOTOR.

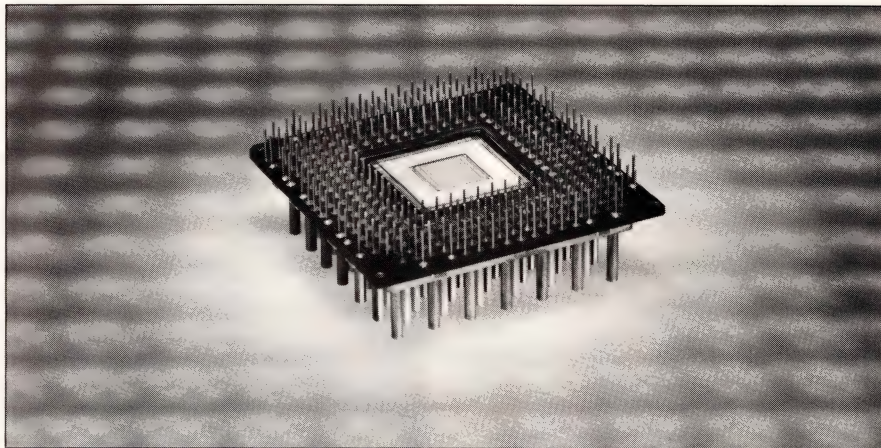


TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

feedback loop you must factor in the additional gate delay, which lowers the frequency characteristics. In addition, the output buffers often must drive capacitive lines, reducing the overall system speed. You're always better off using the gate-delay figures and metal-propagation delay figures given by the vendor in a worst-case, design-analysis-for-speed estimation.

Even noting this caution, some ECL gate array figures are impressive. Sony's E3G200, a 200-equivalent-gate array, specifies a 2.5-GHz flip-flop toggle frequency; the E3G70, a 70-equivalent-gate array, specifies a 3.5-GHz toggle rate. The family boasts a gate propagation delay less than 100 psec. In addition, Fujitsu's ultra-high-performance series features an array, E128H, which has 128 gates with 75-nsec



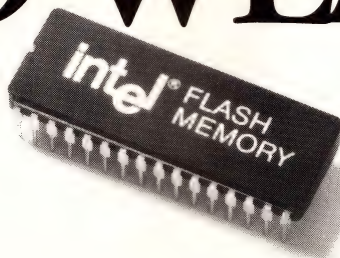
The tape-automated bonding (TAB) process used in the MCA10000ECL series has 360 leads with inner-lead pitches as small as 0.004 in. The tape mounts on a 289 PGA with optional pin-fin heatsinks.

propagation delays, and a specified D flip-flop toggle rate of 4 GHz.

AT&T, which is currently accepting semicustom and custom cell-based design for its BEST-1 series,

specifies a 5-GHz D flip-flop toggle frequency, and an 80-psec gate delay for its high-power version, which dissipates 2 mW per gate. The company claims to have fabri-

4X THE DENSITY OF AN EEPROM. 1/4 THE COST. NO WEAROUT.



TECHNOLOGY UPDATE

cated a 5.2G bps MUX and DEMUX, and a 4.6-GHz frequency divider. A design catalog will be available in the fall.

The ECL gate array provides the designer with a variety of tools for complex designs. But experienced designers know that the user-programmable feature of PLDs offers an advantage in designs requiring gate complexities less than 1000. If you commit a system to ECL logic, there are ECL PLDs to "glue" the pieces together. Because you program these devices yourself, using PLD programmers such as those from Advin (Sunnyvale, CA) and Data I/O Corp (Redmond, WA), they can quickly absolve you of any design sins, or implement custom-logic circuitry.

Cypress Semiconductor has two ECL PLD series that use the indus-

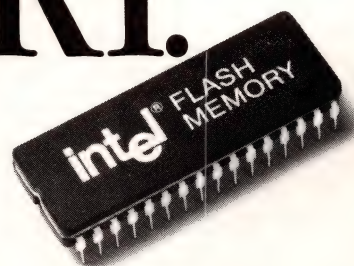
try-standard, sum-of-products architecture for PAL devices. The \$20.50 CY10E301 (10KH-compatible) and CY100E301 (100K-compatible) devices have 16 inputs and eight outputs (16P8 configuration). The high-speed versions have maximum input-to-output propagation delays of 3 nsec, and draw a maximum of 240 mA from the supply. The low-speed versions have input-to-output propagation delays of 6 nsec max, and draw 170 mA max.

The \$26.85 CY10E302 and CY100E302 devices have 16 inputs and 4 outputs (16P4 configuration). The high-speed versions feature a 2.5-nsec, input-to-output delay (max), while drawing 220 mA (max); the low-power versions have 6-nsec delays (max) and draw 170 mA (max). All of the products have output-polarity fuses and a security

fuse for implementing proprietary logic.

National Semiconductor also offers PLDs in the 16P8 and 16P4 PAL configurations. The company offers two families with maximum input-to-output propagation delays of 6 nsec and 4 nsec, respectively. The PALxx16P8 and the PALxx16P4A (\$19.60 and \$25.60, respectively) are combinatorial devices with either programmable or complimentary 10KH- or 100K-compatible outputs. In addition, the series includes PLDs with registered outputs. Devices with either single-clock or dual-clock inputs are available. The high-speed commercial version specifies a minimum 5-nsec setup time for the registers, a maximum clock-to-output time delay of 3.5 nsec, and a maximum clock frequency of 117 MHz.

4X THE DENSITY OF AN SRAM. 1/2 THE COST. NO BATTERY.



TECHNOLOGY UPDATE

ECL-programmable gate arrays and PLDs

For more information . . .

For more information on the ECL gate arrays and PLDs discussed in this article, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

ECL GATE ARRAYS

Applied MicroCircuits Corp
6195 Lusk Blvd
San Diego, CA 92121
Phone (619) 450-9333
Circle No 700

AT&T Microelectronics
Dept 50AL330240
555 Union Blvd
Allentown, PA 18103
Phone (800) 372-2447
Circle No 701

Fujitsu Microelectronics Inc
3545 N First St
San Jose, CA 95134
Phone (408) 922-9000
FAX 408-432-9030
Circle No 702

Motorola Inc
ASIC Division
1300 N Alma School Rd
Chandler, AZ 85224
Phone (602) 821-4406
FAX 602-821-4850
Circle No 703

NEC Electronics Inc
401 Ellis St
Box 7241
Mountain View, CA 04039
Phone (415) 965-6381
FAX 415-965-6752
Circle No 704

Plessey Semiconductor
1500 Green Hills Rd
Scotts Valley, CA
Phone (408) 438-2900
Circle No 705

Raytheon Co, Semiconductor Div
350 Ellis St
Mountain View, CA 94039
Phone (415) 968-9211
FAX 415-966-7620
Circle No 706

Siemens Inc
2191 Laurelwood Rd
Santa Clara, CA 95054
Phone (408) 980-4566
FAX 408-980-4576
Circle No 707

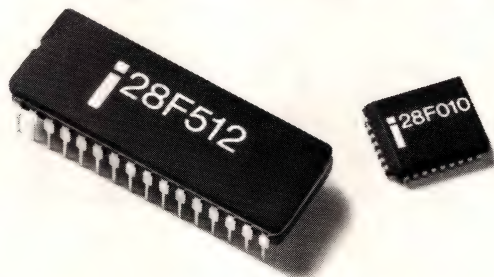
Sony Corp of America
10833 Valley View St
Cypress, CA 90630
Phone (714) 229-4190
FAX 714-229-4271
Circle No 708

ECL PLDs

Cypress Semiconductor Corp
3901 N First St
San Jose, CA 95134
Phone (408) 943-2600
FAX 408-943-2741
Circle No 709

National Semiconductor Corp
2900 Semiconductor Dr
Santa Clara, CA
MS 16-191
Phone (408) 721-5341
FAX 408-245-6340
Circle No 710

NOW YOU CAN HAVE IT ALL. IN A FLASH.



TECHNOLOGY UPDATE

The military version of the registered PLD, the \$29.95 PALxx16RM4A, specifies a minimum 3-nsec register-setup time, a maximum clock-to-output delay of 2 nsec, and a maximum clock frequency of 200 MHz. All of the PLDs come in 24-pin ceramic DIPs and have security fuses to protect proprietary logic. The company's PLAN software package provides an interactive development tool.

The wide range of speed and density for programmable ECL products makes them attractive for applications in supercomputers, mainframes, military systems, optical data links, and ATE. In addition, their flexibility is enhanced by the fact that BiCMOS and GaAs products operate with 10K-, 10KH-, and 100K-compatible I/O signal levels. This compatibility allows you to mix

the logic families without level translators, which operate at lower speeds. **EDN**

References

1. Gallant, John A, "Gallium arsenide digital ICs complement ECL families in high-speed applications," *EDN*, March 3, 1988, p 79.
2. Tomasetta, Louis R, "Processing advances push GaAs ICs to higher VLSI levels," *EDN*, June 9, 1988, p 243.

Article Interest Quotient (Circle One)

High 518 Medium 519 Low 520

WHAT'S NEXT IN EDN

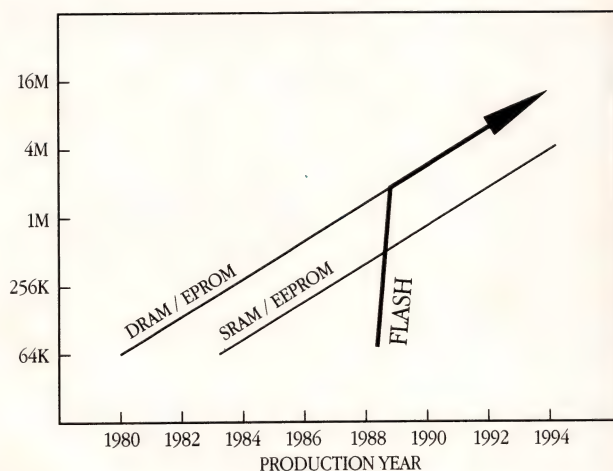
EDN's September 1 issue will feature a staff-written Special Report on nonvolatile memories, including EPROMs, EEPROMs, flash EEPROMs, and one-time-programmable devices. It will also cover real-time kernels for single-chip microprocessors, ASIC verification testers, and how to keep PC data safe. The next installment of Bob Pease's troubleshooting analog circuits series will also appear in this issue.

In our other September issues, look for reports on signal conditioners and 8- and 16-bit microcontrollers.

You won't want to miss any of these issues.

Intel's new Flash Memories. At first, they might sound too good to be true.

But the more you know, the better they get. Because flash gives you the



Flash Memories have overtaken EEPROMs and battery-backed SRAMs. They also give you the density of EPROMs, with rewrite capability, or the density of DRAMs with nonvolatility.

advantages of mainstream memory technologies. Without any of the drawbacks.

In one chip, you get high density.

Read/write capability. Random access. And nonvolatility. All at the lowest system cost.

In fact, Intel's new 28F010 and 28F512 Flash Memories offer so much that they give you a powerful new alternative to EEPROMs. EPROMs. Battery-backed SRAMs. And disk/DRAM combinations. Whether you compare them on performance. On price. Or on reliability.

No matter how you look at it, this is a memory solution you should learn more about. Before your competition does. So call (800) 548-4725, Lit. Dept. #6A14. And we'll send you everything you need to know. In a flash.

intel[®]

©1989 Intel Corporation.

Now You Can Make Important Component Selection Decisions Faster and Easier than You Ever Imagined!



INTRODUCING CAHNERS
CAPS™ ON THE SUN-3™ FAMILY
OF WORKSTATIONS.

THIS NEW, PRODUCTIVITY-
BOOSTING ENGINEERING
TOOL AUTOMATES,
ACCELERATES, AND
OPTIMIZES THE SELECTION
OF INTEGRATED CIRCUITS
AND SEMICONDUCTORS.

CAPS WILL CHANGE THE WAY
YOU WORK!

Imagine having up-to-date information on more than 425,000 devices from over 375 manufacturers worldwide at your fingertips.

Think about instantly accessing crisp, clear, unabridged images of manufacturers' datasheets, with the same text, tables, and graphics found in the printed versions.

Consider applying the power of menu-driven parametric searches that can identify devices which conform to your specifications.

This is CAPS. It's new. It's different. And it gives you all the information you need to make critical component selection decisions.

Available on a subscription basis and updated every month, CAPS comes complete with a four-disc CD-ROM reader, ready to install on your Sun® engineering workstation.

Learn more about how CAPS can take the drudgery out of your component selection process. Call or write:

C A H N E R S
CAPS
Computer Aided
Product Selection

Cahn timers Technical Information Service
275 Washington Street
Newton, Massachusetts 02158-1630
Telephone: 617-558-4960
Facsimile: 617-969-6949
Telex: 940573
Toll-free: 1-800-245-6696

CIRCLE NO 53

CAPS is a trademark of Reed Publishing, U.S.A.

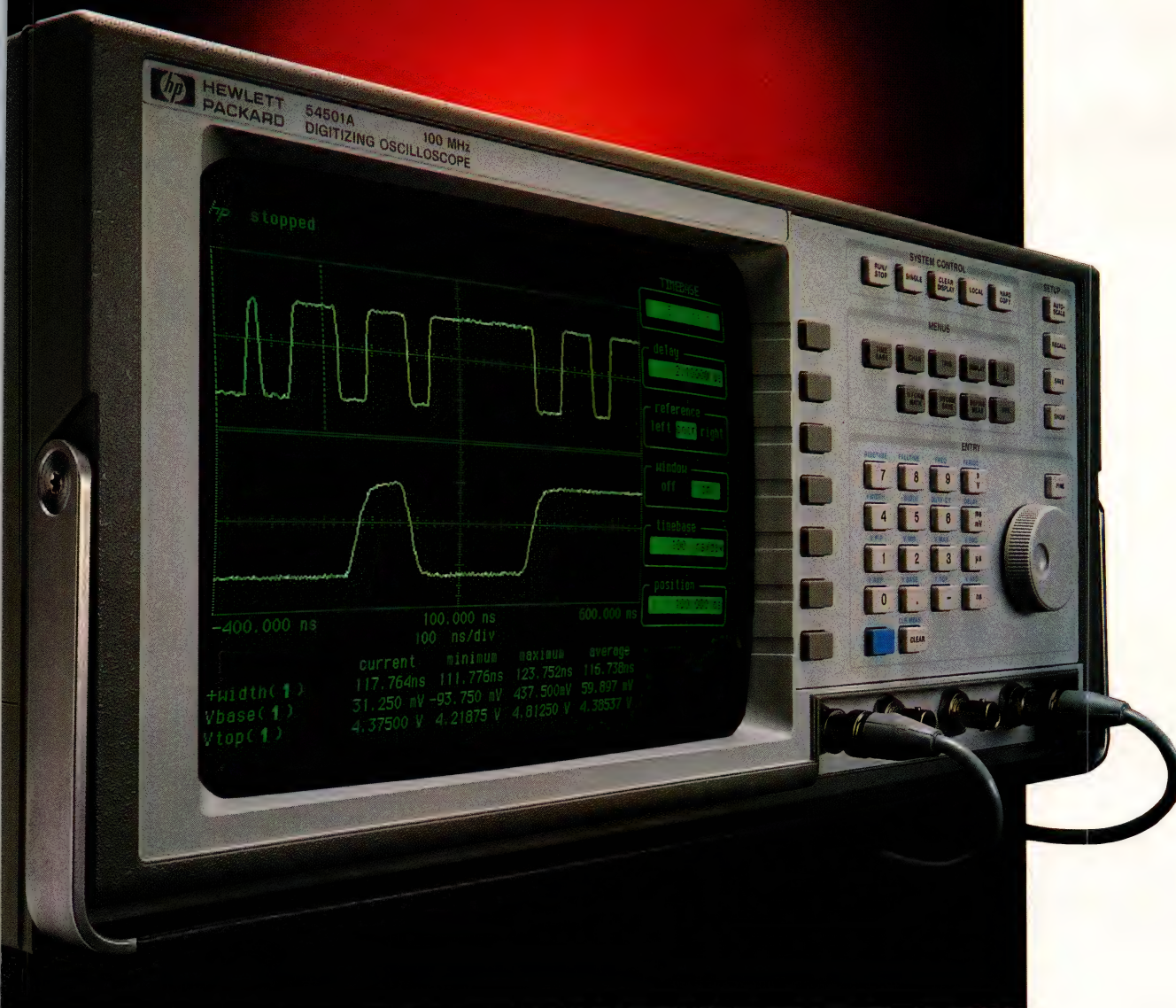
IBM is a registered trademark and AT is a trademark of International Business Machines Corporation.

Sun is a registered trademark and Sun-3 is a trademark of Sun Microsystems, Inc.

Also available on
IBM® PC/AT™ or
100% compatible
personal computers

A scope so good you have to see it.

© 1989 Hewlett-Packard Co. TMC01912F



Unequaled value in a 100 MHz Digitizing Oscilloscope. The HP 54501A.

- 100 MHz bandwidth
- Four channels
- 8-bit vertical resolution
- Instant hardcopy output
- Full HP-IB programmability
- Automatic measurements

Call your local sales office to see the best price/performance, portable, digitizing oscilloscope

on the market. You'll see the power of glitch, dropout and TV triggering, measurement limit test and dual timebase windowing. The HP 54501A outperforms analog oscilloscopes and delivers extra capabilities found only in expensive digitizing oscilloscopes. See the ease and versatility of the HP 54501A.

See the HP 54501A in action.

Contact your local HP sales office for more information.



1750A MICROPROCESSOR AND 1553 SEM E CARD


BUS-67007

DDC's newest Microcomputer SEM E card, the BUS-67007, provides a general purpose, single chip, 16 bit CMOS microprocessor designed for high performance floating point and integer arithmetic, with extensive real time environment support conforming to the MIL-STD-1750A instruction set architecture. The Performance (Pace 1750A) CMOS microprocessor and onboard 32K words of EPROM offers an embedded system controller that can be used as a generic 1750A processor with a BUS-61555, full intelligent dual redundant MIL-STD-1553B Remote Terminal (RTU), Bus Controller (BC), and Monitor (MT). Its RS-422 port facilitates software development and system integration.

The BUS-67007 is packaged on a standard SEM E card with a 150

pin connector. Its on-board 8K x 16 SRAM supports the 1750A CPU. The separate internal 8K x 16 dual access shared RAM of the BUS-61555 AIM-HY supports the 1553B messages, preventing partially updated data from being read by the CPU or transmitted to the 1553 Data Bus. The AIM-HY off-loads the microprocessor from the 1553 communication protocol tasks and offers the host additional RAM for program or data.

Equipped with 8 L.E.D.'s, the card gives visual BIT feedback as to the CPU self-test (green), unrecoverable errors (red), software errors (red), RS-422 status (green), EPROM status (green), SRAM status (green), 1553 terminal self-test status (green), and the CPU watch-dog timer status (green); which can be changed by software

for other future meanings. The BUS-67007, requires only 5 volt DC power, with a total power dissipation under 5 watts.

The Microcircuit, Digital, CMOS, 16-BIT MIL-STD-1750A MICROPROCESSOR, is on DESC drawing #5962-87665-01XC. The PACE 1750A CPU are also available in CMOS/SOS technology for radiation environment applications, in production by 1990. DDC's AIM-HY, BUS-61555 Terminal is on DESC drawing #5962-88692-01XC. The BI-POLAR & CMOS-SOS technology used is available to support tactical and strategic environments.

For additional information on the BUS-67007, contact Steve Friedman at toll-free 1-800-DDC-1772 (outside New York) or call the DDC office nearest you. □


ILC DATA DEVICE CORPORATION

Circle 3 for Sales Contact

Circle 4 for literature

HEADQUARTERS AND MAIN PLANT: ILC Data Device Corporation, 105 Wilbur Place, Bohemia, N.Y. 11716, (516) 567-5600, TLX-310-685-2203, FAX: (516) 567-7358
WEST COAST (CA.): WOODLAND HILLS, (818) 992-1772, FAX: (818) 887-1372;
SAN JOSE, (408) 236-3260, FAX: (408) 244-9767; GARDEN GROVE, (714) 895-9777, FAX: (714) 895-4988
WASHINGTON, D.C. AREA: (703) 893-7989, FAX: (703) 893-7954
NORTHERN NEW JERSEY: (201) 785-1734, FAX: (201) 785-4132
MASSACHUSETTS: (617) 341-4422 or 3128, FAX: (617) 344-1040; JAPAN: (03) 814-7688, FAX: (03) 814-7689
UNITED KINGDOM: 635-40158, TLX: 851-848826; FRANCE: (1) 4-333-5888, TLX: 842-630609
WEST GERMANY: (08191) 3105, TLX: 841-527128; SWEDEN: 8-920-635, TLX: 854-10952



There's a new standard for functionality, ease-of-use and price. The TI-68.

We set some tough goals for ourselves in designing the TI-68. It had to have the powerful functions that technical professionals need. It had to be easy to use. And it had to provide all of this at a substantially lower price than the competition.

We met all of our goals and then some. The TI-68 has 254 useful functions. It solves up to five simultaneous equations with real or complex coefficients. A prompting system guides you through all entries and results. You can handle the complex numbers exactly the way you want, without entering a special mode. The TI-68 evaluates 40 complex number functions and lets you choose polar or

rectangular forms for entries and results.

It also lets you easily check your equations with a 12-character alphanumeric display that can scroll through up to 80 characters for long equations. And, the last equation replay feature lets you edit or check the last computation without having to go back and reenter it.

In addition, when you need to solve quadratic, cubic or quartic equations, the TI-68's polynomial root finder will calculate the real and complex roots — automatically.

Working with number bases and conversions are also no problem. Perform arithmetic functions in decimal, hexadecimal, octal or

binary. And it does Boolean logic operations, too.

The TI-68 provides up to 440 program steps for as many as 12 user-generated formulas. It even stores up to 36 values in memories with user-defined alphanumeric names.

The TI-68 has what you've been looking for — the right functionality at the right price. See and try it at a nearby retailer, or call 1-806-747-1882 for additional information and to request free product literature.

TEXAS
INSTRUMENTS

MSK

Speed Power Precision

MIL-STD 1772 CERTIFIED



OP-AMPS

- OP-AMPS
- CUSTOM HYBRIDS
- DATA CONVERTERS
- POWER HYBRIDS

HIGH SPEED PRECISION LOW BIAS

MSK 739

- 5500V/ μ S Slew Rate
- 30MHz Power Bandwidth
- 15nS 0.1% Settling
- 8nS 1.0% Settling
- 25 μ V Offset Voltage
- 75pA Bias Current
- Replaces AD9610

CIRCLE NO 55

HIGH SPEED PRECISION LOW NOISE

MSK 738

- 3500V/ μ S Slew Rate
- 22MHz Power Bandwidth
- 0.5 μ V/ $^{\circ}$ C Offset Drift
- 0.15 μ Vp-p Noise
- 120mA Output Current
- 25 μ V Offset Voltage
- No Thermal Tail!

CIRCLE NO 56

DUAL HIGH SPEED CURRENT FEEDBACK

MSK 450

- Surface Mount or DIP (Both Mil & Com)
- 2000 V/ μ S Slew Rate
- ± 11 Volts into 500 Ω
- 65 MHz Bandwidth
- $\pm 50\mu$ V Offset Voltage
- $\pm 1.5\mu$ V/ $^{\circ}$ C Offset Drift
- Monolithic Construction

CIRCLE NO 57



HIGH SPEED HIGH VOLTAGE

MSK 600

- 4000V/ μ S Slew Rate
- 200V Output Swing
- 150mA Surge Current
- Low Quiescent Current
- 100MHz Bandwidth
- Excellent Display Amp
- Custom Tailored Designs

CIRCLE NO 58

MSK

M.S. Kennedy Corporation

8170 Thompson Rd., Clay, New York 13041 Tel. (315) 699-9201 Fax (315) 699-8023

Reliability is Honored by Texas Instruments and Hall-Mark.

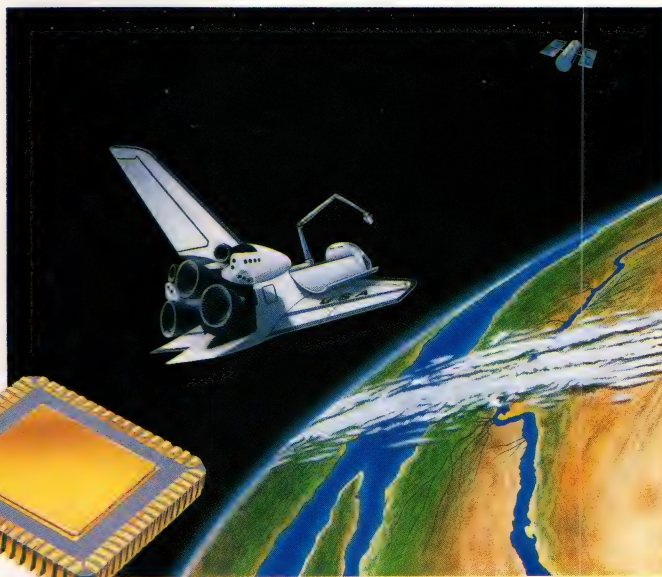
The answer to military product reliability is written on the chip package. If it comes from Hall-Mark and says Texas Instruments, you're assured the product meets the highest standards.

Texas Instruments offers a broad product line for military applications with graphic products, DSP, programmable products, memories, linear and logic devices. Because they're based on the latest proven technologies, often developed by TI, these products will keep your design state-of-the-art throughout the system life cycle.

Work with your Hall-Mark salesperson to select the parts, features and functions you need. To be part of the TI military line they must pass the rigid processing requirements and test methods of MIL-STD-883. The results are parts that meet high-quality, high reliability standards. As a further measure of quality and reliability parts are subjected to a comprehensive Quality Conformance Program by TI. JM38510 (JANB), DESC/Standard Military Drawings, and JEDEC publication 101 Class B (SNJ, SMJ and B) process flows are offered.

TI military parts are currently serving in such diverse applications as avionics, computers, RADARs, missile guidance and controls, communications, SONARs, munitions, countermeasures, satellites, and fire control.

When your product has to be at the ready for a long time, call Hall-Mark to get the Texas Instruments Military products that will perform over the long haul.



Hall-Mark Electronics Corporation • Dallas, Texas

Military solutions.



Alabama
Huntsville (205) 837-8700
Arizona
Phoenix (602) 437-1200
California
Bay Area (408) 432-4000
Orange County (714) 727-6000
Sacramento (916) 624-9781
San Diego (619) 268-1201
San Fernando Valley (818) 773-4500
Colorado
Denver (303) 790-1662

Connecticut
Connecticut (203) 271-2844
Florida
Ft. Lauderdale (305) 971-9280
Orlando (407) 830-5855
Tampa Bay (813) 541-7440
Georgia
Atlanta (404) 447-8000
Illinois
Chicago (312) 860-3800
Indiana
Indianapolis (317) 872-8875

Kansas
Kansas City (913) 888-4747
Maryland
Baltimore (301) 988-9800
Massachusetts
Boston (617) 935-9777
Michigan
Detroit (313) 462-1205
Minnesota
Minneapolis (612) 941-2600
Missouri
St. Louis (314) 291-5350

New Jersey
Fairfield (201) 575-4415
Mt. Laurel (609) 235-1900
New York
Long Island (516) 737-0600
Rochester (716) 425-3300
North Carolina
Raleigh (919) 872-0712
Ohio
Cleveland (216) 349-4632
Southern Ohio (614) 888-3313

Oklahoma
Tulsa (918) 254-6110
Pennsylvania
Philadelphia (215) 355-7300
Texas
Austin (512) 258-8848
Dallas (214) 553-4300
Houston (713) 781-6100
Washington
Seattle (206) 547-0415
Wisconsin
Milwaukee (414) 797-7844

© 1989 Hall-Mark Electronics Corporation/400-3104

CIRCLE NO 54



The Bettman Archive, Inc.

Balancing mechanical and electrical requirements keeps us on the leading edge of interconnect technology.

What a challenge: making cable systems smaller, lighter, and more flexible without compromising signal fidelity, flex-life, or reliability. At Precision Interconnect we do it every day, for leading electronic equipment manufacturers all over the world.

Working with a variety of mechanical requirements, plus strict electrical parameters, we custom-design and produce complete interconnect systems. Micro-miniature cables, usually using 38 AWG and smaller conductors, can be terminated to standard or micro connectors and protected with flex-strain

reliefs. Custom overmolds and sealing designs have been developed to protect interconnect systems in harsh environments. These cable assemblies provide the critical link in hand-held applications on diagnostic instruments, sensors, and medical and surgical devices.

Our expertise, increasing with each unique problem we solve, ensures that reliability is designed in, built in, and tested.

So we can keep our balance. And assure a great performance every time.



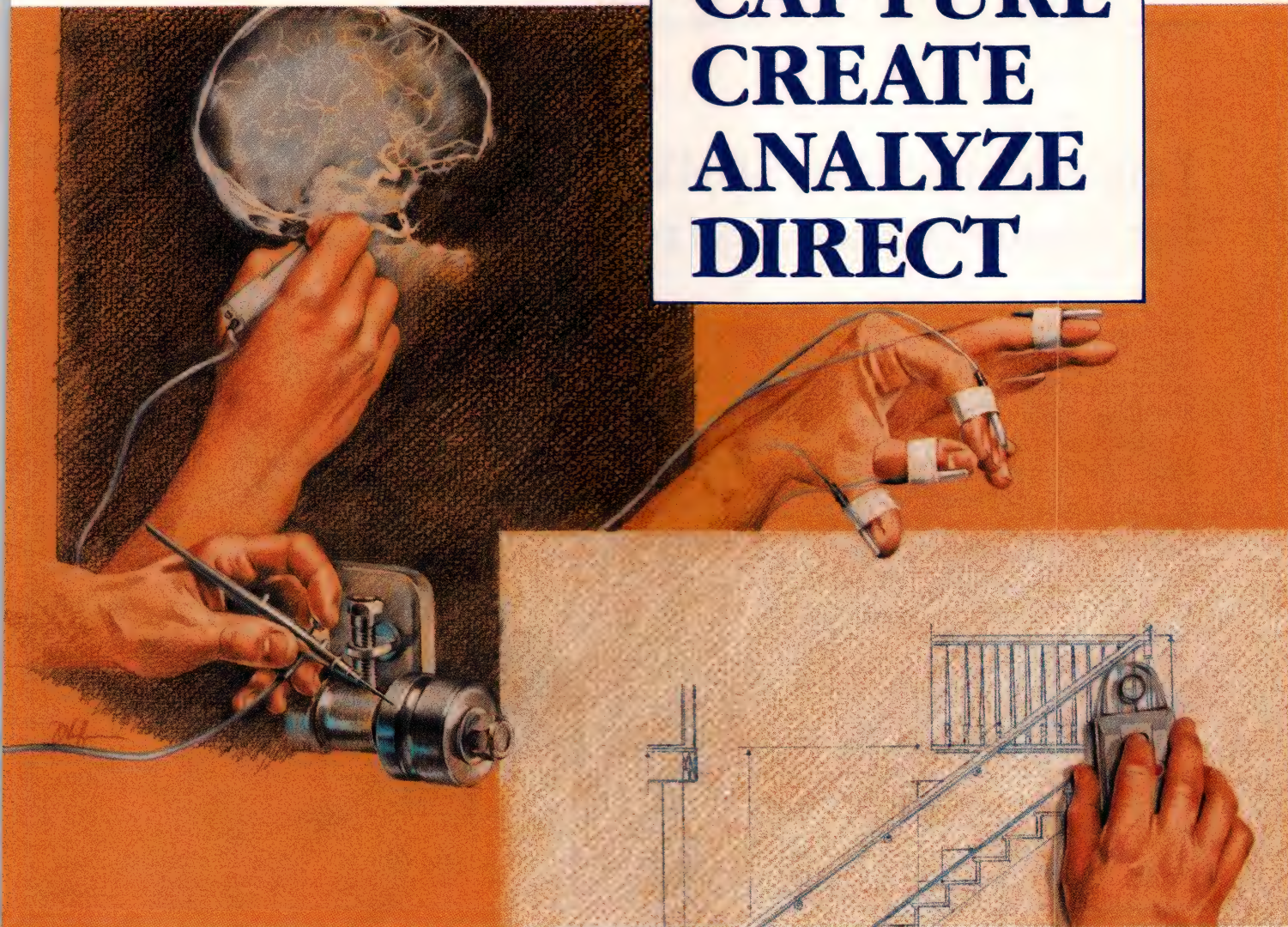
**PRECISION
INTERCONNECT**

16640 S.W. 72nd Avenue
Portland, OR 97224
(503) 620-9400

Interconnect assembly for Medical Dynamics' hand-held surgical camera is sealed against sterilization solutions.



CAPTURE CREATE ANALYZE DIRECT



...with sonic digitizers

Capture...

input data from film transparencies, projections, hardcopy, 3-D objects and motion. From any surface in any orientation...with 2-D formats up to 60" x 72" and 3-D objects within a 9 foot cube. In data output formats to suit your specific needs.

Create...

a variety of graphic images. From the simplest of 2-D formats to the most complex 3-D animated images. Generate contour images and dimensions of solid objects. Creates animation databases for use in film production, robotics and a host of other applications.

Analyze...

input data from any source document, drawing, 3-D objects or forms in motion...to provide cost estimates from drawings...generate contour images of solid objects...real-time multipoint analysis of humans and objects in motion.

Direct...

robotics, CAM, CIM and a multitude of other automated and semi-automated systems and equipment. Capture and analyze the input data from its source, then format it to drive your system.

Digitizing Today... With Tomorrow's Technology

In use today, around the world as integrated workstation components or add-on systems to computer devices. Serving business, construction, industrial and medical applications.

Call or write today to discuss your special requirements. We will customize to meet your specifications.

CIRCLE NO 61

**SAC[®] SCIENCE
ACCESSORIES
CORPORATION**

200 Watson Boulevard P.O. Box 587
Stratford, CT 06497
(203) 386-9978 FAX (203) 381-9270 Telex 964300

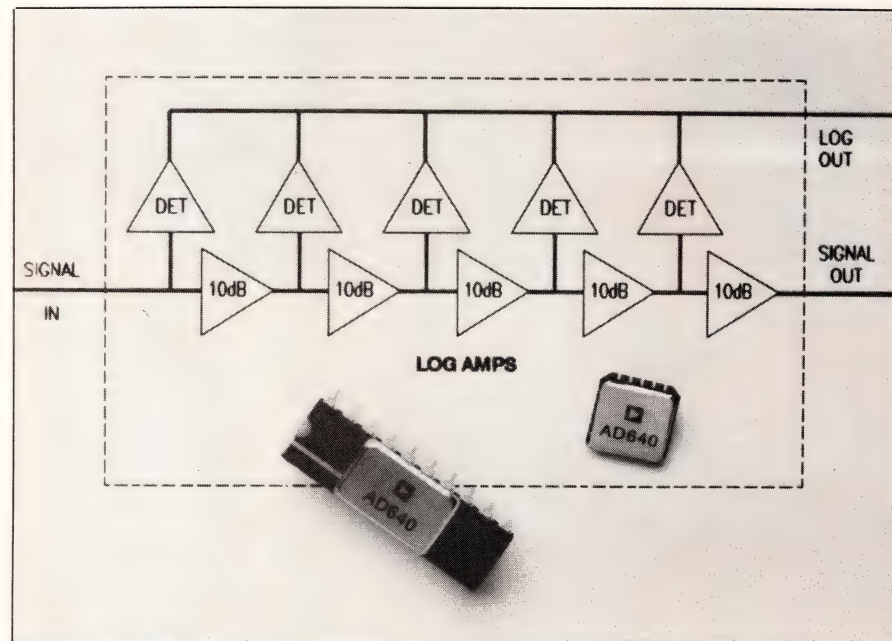
Log amp features 50 dB of dynamic range for input frequencies from dc to 120 MHz

The AD640 dc-coupled logarithmic amplifier is a monolithic, completely analog device that features a dynamic range of 50 dB, a maximum dc nonlinearity of ± 0.6 dB, and a 120-MHz bandwidth. Log amps are useful in such instrumentation applications as spectrum and network analyzers, and they can compress wideband data prior to A/D conversion, thereby reducing the A/D converter's dynamic-range requirements.

The log amp uses a successive-detection scheme to provide an output current proportional to the input voltage's logarithm. You can convert the differential-output current to a voltage by using the device's internal resistors and a high-speed op amp.

The log amp is unique because it integrates five cascaded, dc-coupled, amplifier-limiter stages in one IC. Each stage has an associated full-wave detector whose output current depends on the absolute value of its input voltage. The five outputs are summed to provide the video output, which is scaled at 1 mA per decade or 50 μ A per dB. The bandwidth of each stage has a small-signal voltage gain of 10 dB and a -3-dB bandwidth of 350 MHz. The bandwidth of all five stages together is guaranteed at 120 MHz.

Two key performance features of the log amp are its full calibration and its temperature performance. The device's logarithmic response is absolutely calibrated to within ± 1 dB for dc or square-wave inputs from ± 0.75 mV to ± 200 mV; the scaling is also guaranteed for sinusoidal inputs. An internal X10 attenuator provides an alternative in-



The AD640 log amp integrates five detector stages to provide 50 dB of dynamic range, and is fully calibrated for stable performance over its entire temperature range.

put range of ± 7.5 mV to ± 2 V dc. The intercept voltage (the input voltage for which the log amp's output is zero) is calibrated to exactly 1 mV. The log amp's internal architecture minimizes thermally induced errors so that the logarithmic slope, intercept voltage, and ac response are stable over the full military temperature range.

You can cascade two log amps by simply tying the balanced signal output from the first amp to the input pins of the second amp. However, because of noise coupling between the two amps, cascaded configurations require a tradeoff between bandwidth and dynamic range. You can achieve a higher dynamic range of 95 dB at a reduced bandwidth of 10 Hz to 100 kHz by including a low-pass filter between the two devices. For bandwidths of 50 to 150 MHz, the two cascaded

converters can achieve a dynamic range of 70 dB.

The log amp operates from ± 4.5 to ± 9 V supplies (± 5 V typ), and consumes a maximum of 375 mW. The device is available in industrial (-40 to $+85^\circ\text{C}$) and military (-55 to $+125^\circ\text{C}$) temperature ranges. Both devices are available in either 20-pin LCCs or ceramic DIPs. The industrial ceramic-DIP version costs \$60 (100).

—Anne Watson Swager

Analog Devices, Box 9106, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 730

1985

SONY EXPANDS SRAM LINE.

CYPRESS, CA - Sony announces a major expansion in its SRAM line. Now, OEMs have a wider choice in Sony SRAMs than ever before. Many package densities are available including 16K.

Packages are available in 600 mil DIP and 300 mil DIP, depending on your choice.

Sony report
market share
market, bey
ent Produ
tations.

CYPRESS, CA -- Sony makes a major commitment to the high-speed, high-density SRAM market. A range of models are available in various speeds and densities, in SOP

only the beginning of Sony's high-speed, high-density SRAM thrust. Sony engineers report higher speed, higher density models available soon. Sony Component Product

**HIGH-SPEED,
HIGH-DENSITY SRAMS
IN LEAST.**

...EVEN FASTER.

CYPRESS, CA - Sony Composites Products Division continues dramatic rise in high-speed, high-density GRAB... all new...

OEMs are benefiting more than ever before. Sony Composites Division plans to...

1986-1988

Tomorrow

Not Bad For A Five Year Old.

Today

For full details, call (714) 229-4197 today. Or write Sony Corporation of America, Component Products Division, 10833 Valley View St., Cypress, California 90630, Attn: Semiconductor sales. FAX (714) 229-4271.

SONY®

SONY®

Sony is a registered trademark of Sony Corporation.

SONY HIGH-SPEED, HIGH-DENSITY SRAMS.			
MODEL	CONFIGURATION	SPEED (ns)	PACKAGE
CXK5863P	8K x 8	25/30/35	DIP 300 mil
CXK5863M	8K x 8	25/30/35	SOP 450 mil
CXK5863J	8K x 8	25/30/35	SOJ 300 mil
CXK5464AP	16K x 4	25/30/35	DIP 300 mil
CXK5464AJ	16K x 4	25/30/35	SOJ 300 mil
CXK5465P*	16K x 4	25/30/35	DIP 300 mil
CXK5465J*	16K x 4	25/30/35	SOJ 300 mil
CXK5164P	64K x 1	25/30/35	DIP 300 mil
CXK5164J	64K x 1	25/30/35	SOJ 300 mil
CXK5971P	8K x 9	25/30/35	DIP 300 mil
CXK5971J	8K x 9	25/30/35	SOJ 300 mil
CXK58258AP	32K x 8	25/30	DIP 300 mil
CXK58258AJ	32K x 8	25/30	SOJ 300 mil
CXK58258P	32K x 8	35/45	DIP 600 mil
CXK58258SP	32K x 8	35/45	DIP 300 mil
CXK54256P	64K x 4	35/45/55	DIP 300 mil
CXK51256P	256K x 1	35/45/55	DIP 300 mil
*O/E			

EDN INFO CARDS

THE
1½¢
SOLUTION

to your marketing budget blues—the EDN Info Card Pack. At 1½¢ per name, the EDN Info Card Pack can reach over 123,000 engineering specifiers affordably.

EDN Magazine
Edition
News
Edition

A Partnership in Power and Prestige Worldwide


PHILIPS


When speed counts...

PM 6654C - the fast counter for signals up to 2.3 GHz

When it's speed that counts, the Philips PM 6654C is the first to finish. With its 500 MHz real-time clock resolution, this sprinter puts 9 digits on display in just one second.

On time measurements, single-shot resolution is an excellent 2 ns. And if that's not enough, resolution is **an incredible 1 ps** on averaged repetitive time intervals. And this performance is reached fast: high-speed averaging gets down to 100 ps resolution on a 1 ms measurement!

GPIO performance is just as impressive. The PM 6654C can transmit up to 420 measurements/s — and 100% bus programmability allows instrument performance to be

utilized to the full in automated measuring system environments.

Complementing the PM 6654C's unbeatable speed is its great versatility: 14 measuring functions and a bandwidth from DC to 2.3 GHz (with optional RF input) cover virtually every requirement.

Making PM 6654C the only choice... when speed counts.

For further information, call your local supplier:

Austria (0222) 60101-1772, Belgium (02) 5256692/94, Denmark (01) 572222, Finland (0) 5026371, France (1) 49428080, Germany (561) 501466, Great Britain (023) 240511, Ireland (01) 330333, Italy (039) 3635240/8/9, Netherlands (13) 352455, Norway* (2) 680200, Portugal* (1) 683121, Spain (1) 4042200, Sweden (8) 7031000, Switzerland (1) 4882390.

*For Philips products only.

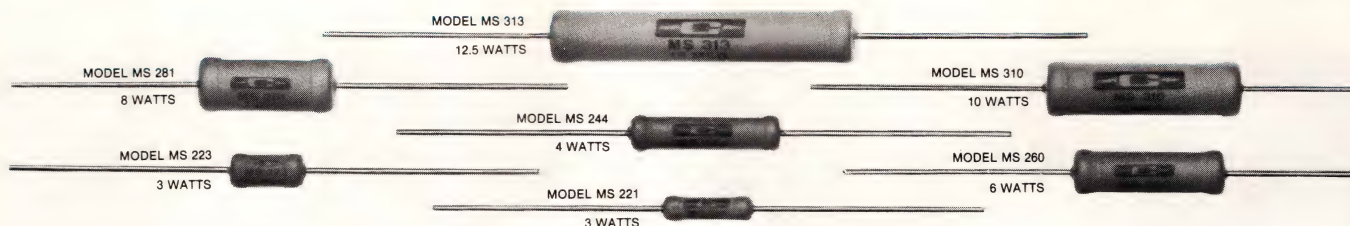
For countries not listed, write to: Philips I&E, T&M Department, Building HKF 5600 MD Eindhoven, The Netherlands.



**ADVANCED TECHNOLOGY
MADE TO MEASURE**


PHILIPS

Type MS Non-Inductive Power Film Resistors from CADDOCK optimize high-speed power switching:



1. Caddock's "Non-Inductive Design" can improve rise and fall times to minimize losses in power switching circuits.

To keep the inductance to an absolute minimum, the special serpentine pattern provides for neighboring lines to carry the current in opposite directions to achieve maximum cancellation of flux fields over the entire length of the resistor.

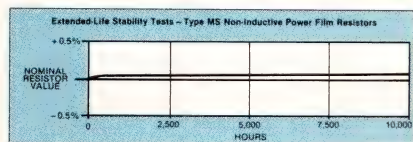


The result is a truly non-inductive resistor that is about as inductive as a straight piece of wire the length of the resistor body.

This makes it possible for engineers to design new circuit configurations with superior non-inductive performance.

2. Extended-life stability that is typically better than 0.05% per 1000 hours.

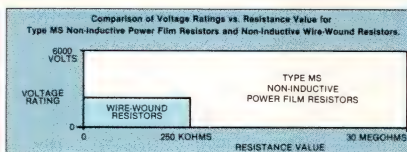
Extended load-life tests at full power have demonstrated typical stability better than 0.05% per 1000 hours.



Detailed stability data is included in the "Reliability Test Summary - Caddock Report #1" which is available on request.

3. Critical resistance values extended by higher voltage and power ratings.

Caddock's Micronox® film resistor technology permits single-resistor voltage ratings as high as 6000 volts to be combined with power ratings of 12.5 watts at +25°C. This combination of power and voltage provides a critical resistance value of 2.88 Megohms - more than 10 times higher than can be achieved with wire-wound construction.



The higher voltage rating of Type MS resistors also overcomes the resistance value limits imposed on wire-wounds by the minimum wire size and spacing.

4. The special construction of Micronox® resistors assures high performance through harsh environments.

Type MS Power Film Resistors are produced by firing high-stability Micronox® resistance films directly onto a solid ceramic core - in air - at +1400°F to achieve a structure with these special performance advantages:



- Operating temperatures as high as +275°C.
- Repeatable temperature characteristics that include a TC of only 50 PPM/°C.
- Verified reliability through environmental extremes encountered in both 'down-hole' oil exploration and deep-space instrumentation equipment.

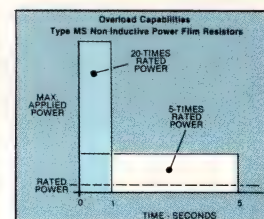
5. The family of Type MS Power Film Resistors includes 14 models with single-resistor values to 30 Megohms.

To overcome the construction and cost limitations inherent in wire-wound resistors, Caddock Micronox® film resistor technology gives circuit designers a practical balance between performance, value, size and cost, as the specifications for the Model MS 313 demonstrate:

- Non-inductive performance.
- 12.5 watt power rating.
- Resistance values from 50 ohms to 30 Megohms.
- Resistance tolerances from $\pm 1.0\%$ to $\pm 0.1\%$.
- Maximum operating voltage of 6000 volts.
- Unit prices below \$2.50 on 1000-lot orders for any value between 100 ohms and 200 Kohms.

6. Overloads of 5-times rated power for 5 seconds and 20-times rated power momentary are standard on all models.

After repeated power overload tests that apply 5-times rated power for 5 seconds, Type MS resistors have demonstrated stability typically better than 0.1%.



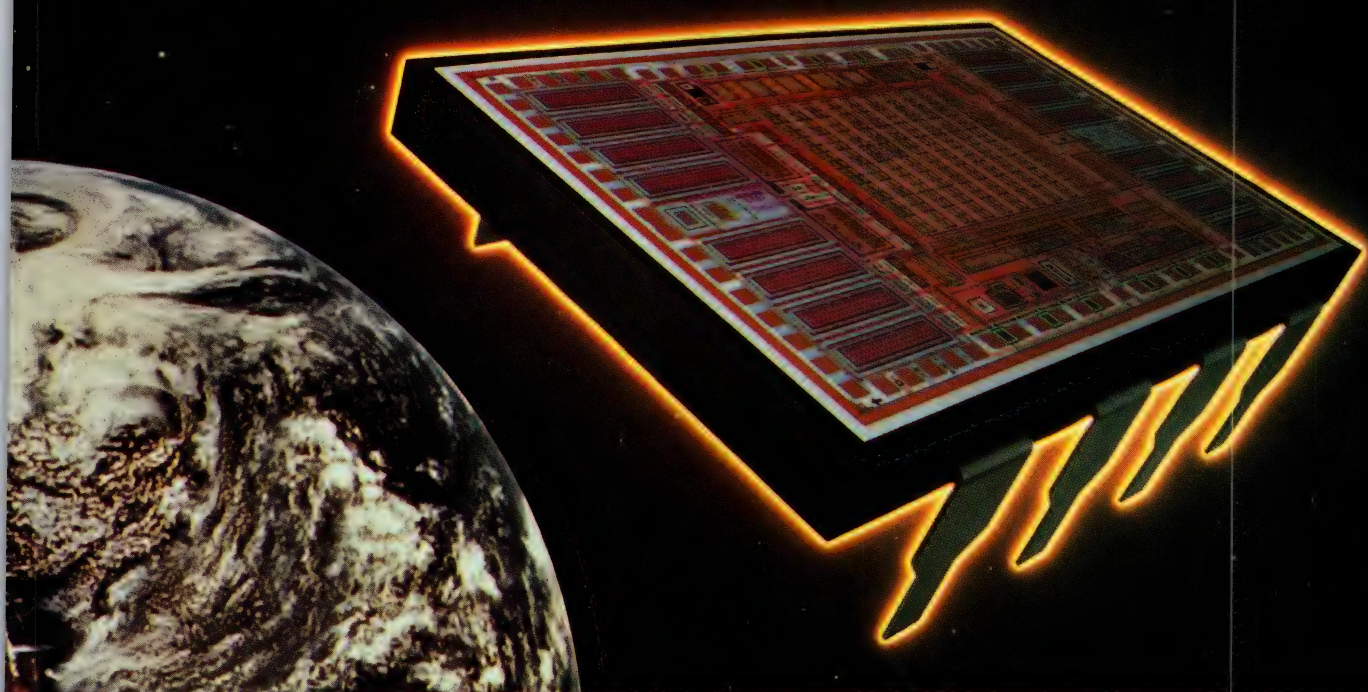
For even higher overload situations, Type MS resistors can be subjected to 20-times the rated power for one second.

Caddock's advanced film resistor technology is the source of these outstanding advantages—advantages that are matched by a 25-year record of outstanding 'in-circuit' reliability.

Discover how easily these problem-solving resistors can improve the performance and reliability of your equipment, too. For your copy of the latest edition of the Caddock 28 page General Catalog, and specific technical data on any of the more than 200 models of the 19 standard types of Caddock High Performance Film Resistors, just call or write to—

Caddock Electronics, Inc., 1717 Chicago Avenue, Riverside, California 92507 • Phone (714) 788-1700 • TWX: 910-332-6108

CADDOCK
HIGH PERFORMANCE FILM RESISTORS



MICREL DELIVERS SMART POWER TO RUN THE WORLD.

With the new high voltage MPD8020 CMOS/DMOS/Bipolar semi-custom array.

Now you can use Micrel's MPD8020 to manage and deliver controlled smart power anywhere for real world work.

Run and control motors, switch regulators, drive lamps, power displays, control relays and solenoid drivers, run printers and so much more where you're putting big electrical energy to work running the world.

This extraordinary array, which can be tailored to your exact needs in just 45 to 60 working days, combines CMOS analog circuits, TTL/CMOS compatible high speed CMOS logic, and high voltage DMOS power drive circuits in one monolithic IC.



For Switched Mode Power Supplies.

25 to 100 Volts. Small size, up to 1MHz switching. Full and half H-bridge configurations. DMOS FETS source/sink. "Bulletproof circuits" provide overcurrent, overvoltage and over-temperature protection.



For Military Avionics.

80 Volts peak, 28 Volts operating (more than 50% derated), capable of meeting MIL SPEC 704. Use for mil spec displays, pin diode drivers, lamp drivers, compact actuator controls, relay drivers, fly-by-wire controls. Wide environmental tolerance. High MTBF. Lightweight, and small size.



For Telecommunications.

48 Volts for the central office. VLSI to reduce circuit board real estate. A perfect choice for card cages and subscriber sets. Shrink the size, increase features and reliability.



For Computer Peripherals, Office Equipment, and Industrial Controls.

24 Volts operating, 100 Volt peak allows >50% derating for ruggedness. From FAX to friction. 16 solenoid drivers on a single chip. High efficiency and low development cost. 5V to 15V controls high current and or high voltage. Customize your I/O. High side driver improves safety. Half, full or 3-phase H-bridge configurations are great for HVAC control, machine driver control, and robotics.



For Medical Equipment.

80 to 100 Volts. High voltage for feedback and physiological needs. Semi-custom array cuts costs, lowers size, reduces parts count, increases features, and improves reliability.

Sixteen Page Data Sheet Yours For the Asking.

For your copy and other information, please address Micrel Semiconductor, 560 Oakmead Parkway, Sunnyvale, CA 94086. Phone (408) 245-2500. FAX (408) 245-4175.

MICREL
SEMICONDUCTOR
THE INTELLIGENT POWER COMPANY™

REAL-TIME

EDN SPECIAL REPORT



*Ada supports the enormous, complex programs that are vital to real-time military systems.
(Photo courtesy Alslys Inc)*

Ada



The growing use of 32-bit μ Ps, with their 4G-byte address spaces, allows engineers to create embedded systems incorporating truly gargantuan programs. Popular programming languages are hard pressed to support programs forged with megabytes of code, but Ada meets that challenge.

Steven H Leibson, Regional Editor

"Please put down your weapon. You have 20 seconds to comply," stated the ED-209 law-enforcement droid.

The intimidated junior executive dropped his chrome-plated pistol like a hot potato. This boardroom demonstration had gone far enough. Unfortunately, the junior exec's conciliatory action went unnoticed by the ED-209.

"You now have 15 seconds to comply," it said. The droid proceeded to count down the seconds as the other executives scurried out of the way. Meanwhile, a host of technicians tried to shut down the ED-209.

"I am now authorized to use force," said the droid, as it blasted the unfortunate junior executive into oblivion with its automated weapons.

The corporate CEO looked up at his senior VP, the man responsible for the ED-209 project, and said "Dick, I'm very disappointed."

"I'm sure it's only a glitch," replied the senior VP.

This scene from Orion Pictures' 1987 movie *Robocop* may seem fantastic, but it illustrates the very real problems engineers face today as they give real-time embedded systems expanding physical abilities and ease humans out of the control loop. We already entrust machines far more dangerous than the ED-209 to embedded-computer control. Computers now run such items as mechanical and chemical manufacturing plants and nuclear-tipped cruise missiles. As embedded-control computers continue to find their way into complex military systems and commercial products, the enhanced functions of these systems press engineers and programmers to create increasingly complex software. Although computers can serve as very reliable overseers, a programming error in a real-time embedded system can have costly, or even fatal, consequences. The Ada programming language was created with these issues in mind.



Ada and a personal computer from Zenith operate this UH-60A Black Hawk helicopter trainer for the army. The Ada development system is from Alslys. Many flight simulators and trainers, excellent examples of real-time applications, now incorporate Ada code. (Courtesy Validity Corp)

In the 1970s, the DoD started to take a serious look at its software-procure- ment policies.

The US Department of Defense (DoD) has a keen interest in using computers to control physical processes in air, land, sea, and space vehicles, as well as in weapons systems. Hence, the DoD has been doubly concerned about the safety, reliability, maintainability, and cost of the software that runs such systems, and decided in the 1970s to seriously examine its software-procurement policies. The DoD's software study in 1974 showed a reversal of the ratio of hardware to software procurements from the 1950s to the 1980s. In the 1950s, 80% of the DoD's acquisition budget for new systems was used for hardware, and the DoD projected that software would consume that percentage in the 1980s. That projection was correct; by 1990, the DoD will be spending more than \$10 billion a year on software.

The 1974 study also revealed that DoD contractors were using several hundred programming languages and dialects to create defense systems. This multitude

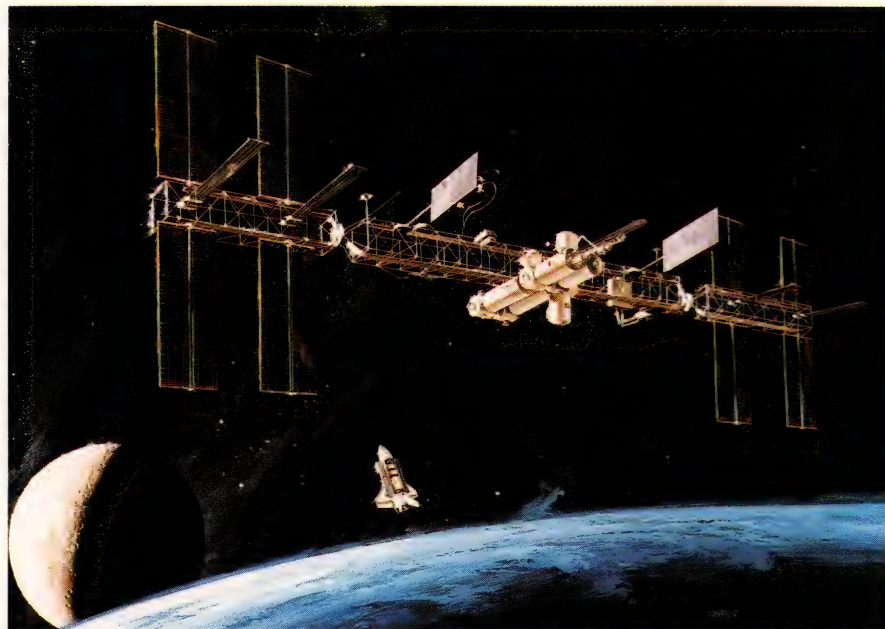
of diverse languages was causing support costs to skyrocket. Some of these languages were so esoteric that only a few programmers were skilled in them, guaranteeing maintenance problems in years to come. When a deployed system can no longer be supported, it must either be totally redesigned or scrapped.

The software monster grows exponentially

Software program size has grown exponentially over time with each new deployed system (Fig 1) as more powerful military computers have become available. In addition to jet fuel, the B2 bomber will fly on an estimated 2M lines of code (LOC). The software programs for both the ATA and ATF advanced military aircraft projects will run an estimated 10M LOC each. NASA has adopted Ada as the official programming language of the Space Station Freedom Project, and expects the computerized systems aboard the space station—as well as the associated ground-support sys-

**TABLE 1—REPRESENTATIVE ADA DEVELOPMENT
SYSTEMS FOR EMBEDDED REAL-TIME APPLICATIONS**

VENDOR	COMPILER	HOST CPU	TARGET PROCESSOR	PRICE
AITECH	AI-ADA/020	DEC VAX/VMS	68020	\$12,500–\$79,875
	AI-ADA/88K	DEC VAX/VMS	88000	\$40,000–\$80,000
ALSYS	C11rX68	DEC VAX/VMS	68000/10/20/30	\$35,000 FOR VAX 62XX, 8300, 8350, AND 8530. PRICES VARY FOR OTHER VAX MODELS.
	P07-C12-X68	HP9000/300	68000/10/20/30	\$20,000
	P07-C15-X68	SUN 3	68000/10/20/30	\$20,000
	P07-C19-X86	IBM PC (286 OR 386)	8086/186/286	\$20,000
	P07-C28-X68	IBM PC (286 OR 386)	68000/10/20/30	\$20,000
	P07-C36-X68	APOLLO WORKSTATIONS	68000/10/20/30	\$20,000
DDC-1	DACSr80 x 86	DEC VAX/VMS	8086/186/286/386	\$30,000–\$90,000
INTEL	VVSADA386	DEC VAX/VMS	80386	\$24,000–\$86,000
	VVSADA960	DEC VAX/VMS	80960	\$28,000–\$90,000
INTERACT	1750A CROSS-COMPILER SYSTEM	DEC VAX/VMS	1750A	\$8000–\$100,000
NATIONAL	NSW-ADA-BRVM	DEC VAX/VMS	32000 FAMILY	\$43,500–\$88,000
RATIONAL	1750A CROSS-DEVELOPMENT FACILITY	RATIONAL R1000	1750A	\$31,850–\$78,400
	68000 CROSS-DEVELOPMENT FACILITY	RATIONAL R1000	68000/10/20	\$31,850–78,400
READY SYSTEMS	RTADA/SUN TO 68020	SUN 3	68020	\$19,500
	RTADA/VMS TO 1750A	DEC VAX/VMS	1750A	\$22,500–\$98,000
	RTADA/VMS TO 68020	DEC VAX/VMS	68020	\$19,500–\$89,000
SOFTECH	ADA-86	DEC VAX/VMS	8086/186/286/386	
TARTAN LABS	VMS 1750A	DEC VAX/VMS	1750A	\$15,000–\$90,000
	VMS 68K	DEC VAX/VMS	68000/10/20	\$15,000–\$90,000
TELESOFT	TG2027X	DEC VAX/VMS	68000/10/20	\$15,000–\$80,000
	TG2031X	DEC VAX/VMS	1750A	\$15,000–\$86,000
VERDIX	VADS	DEC VAX/VMS	1750A	\$15,000–\$70,000
	VADS	SUN 3, DEC VAX	68020/030	\$15,000–\$70,000
	VADS	DEC VAX/VMS	80386	\$20,000–\$75,000



NASA's Space Station Freedom Project employs Ada as the primary programming language for all mission software in flight hardware and for ground support. The space station will incorporate 10 distributed-computer networks to operate the onboard systems.

tems—to require several million LOC. These larger programs take much longer to write, and this situation often leads to slipped schedules and ruined budgets. In addition, imperfect coupling between blocks of code written by different programmers or programming groups often causes large programs to be infested with bugs.

Because exponential program growth, plagues of program bugs, cost overruns, and missed deadlines were ominous trends, the DoD formed the High Order Language Working Group in 1975 to determine whether a single programming language could meet all of the DoD's software needs. After years of effort, the result of that work is the Ada programming language, MIL-STD-1815A. The DoD trademarked the name "Ada" so it could maintain control over the language. To be legally called an Ada compiler, a compiler must pass a suite of more than 3000 validation tests and be revalidated annually. The DoD doesn't validate supersets or subsets of the language.

Ada is a complex programming language that was designed for writing very large programs, so most Ada compilers generate code for 32-bit processors. A few 16-bit μ Ps are also supported. In addition, most Ada development systems run on minicomputers (the Digital Equipment Corp's VAX series is generally preferred), and a few run on engineering workstations and high-end PCs. Table 1 lists several Ada development systems for real-time applications.

Although initially created for defense systems, Ada's features are designed to solve problems encountered by both commercial and military software projects. Even though both military and civilian project planners are concerned about correct and reliable code that can be easily maintained, Ada was used first for defense systems, because of the so-called Taft directives. Cre-

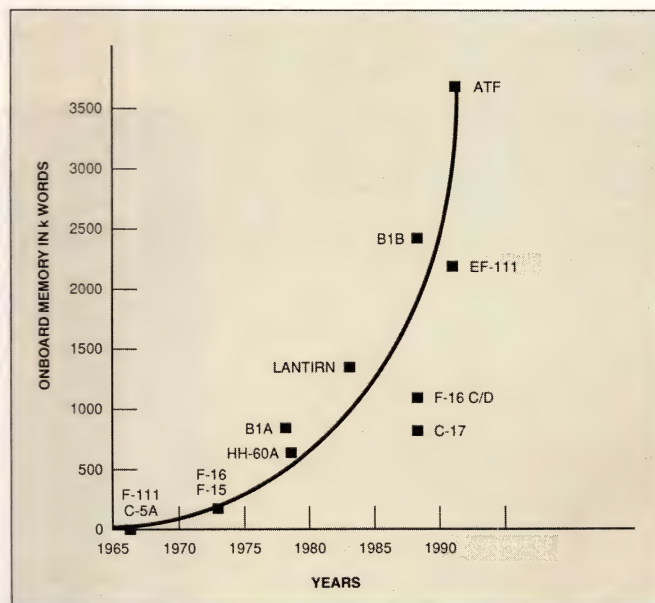


Fig 1—Program size in deployed defense systems has risen exponentially over time since the introduction of military computers.

Ada's features are designed to solve problems encountered by both commercial and military software projects.

ated in 1984, the Taft directives require all new software and major software upgrades for mission-critical systems to be written in Ada. In previous years, the DoD issued many waivers to the Taft directives, but the growing number of validated Ada compilers and improving Ada compiler technology will make those waivers harder to get.

Meanwhile, success stories about Ada are starting to appear, primarily in military systems (thanks to the Taft directives). Ada has been used successfully for aircraft trainers, such as the UH-60A Black Hawk Composite Trainer built by Validity Corp (Encinitas, CA), and for missile guidance systems, such as the improved Hellfire missile developed by Rockwell International's Missile Systems Division (Duluth, GA). These two applications have stringent real-time requirements.

Commercial companies are also starting to use Ada in operational systems. Volvo in Sweden and Citroën in France use Ada for robotic assembly of automobiles. Several telecommunications companies are gearing up to use Ada for central-office switching applications. Appropriately enough, considering its focus on large programming projects, Ada is being used for the world's largest computer system—the global telephone network.

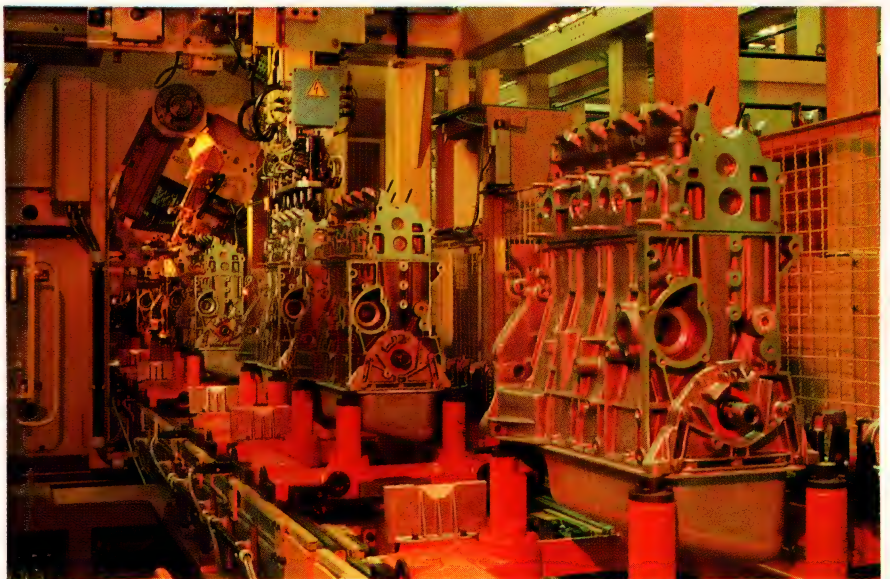
NASA selected Ada as the primary programming language for the Space Station Freedom Project because the space station's software programs will be of staggering size, even by the limits now set by military systems. When it flies in the mid 1990s, the space

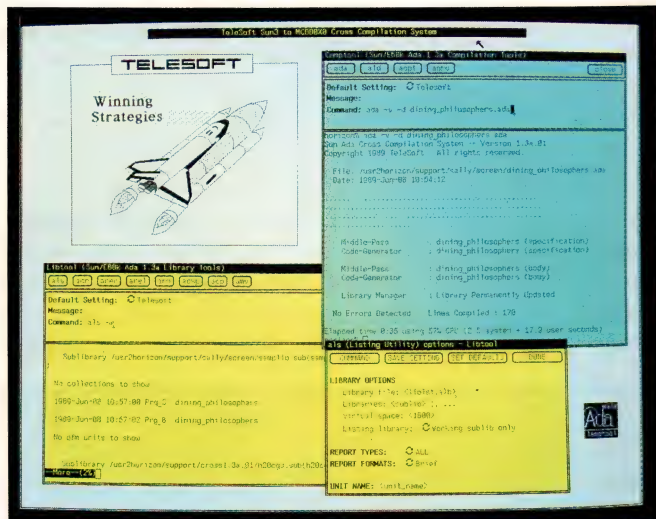
station will incorporate 10 computerized control systems built from distributed μ P networks. These computerized control systems will operate the facility's propulsion; guidance and navigation; electrical power; thermal- and fluid-management; operations- and data-management; and communications and tracking systems.

Despite these successes, the earliest attempts to use Ada for real-time applications failed because the compilers were immature, and because nobody knew how to employ the language to create real-time systems. These early failures make great horror stories; you've probably heard or read many negative opinions about the language (in addition to some of the propaganda disseminated by Ada boosters). To evaluate Ada objectively as a development tool for your next real-time project, you must first shed the myths that have grown around the language.

MYTH: Ada was designed by committee and looks like a camel that was supposed to be a horse. In reality, Ada was not designed by committee. Dr David Fisher at the Institute for Defense Analyses created a draft requirement called Strawman that defined a universal programming language for the DoD's software needs. Based on comments from both military and civilian advisors, this draft went through two revisions, dubbed Woodenman and Tinman. No existing programming language met all of the requirements of the Tinman specification, so in 1977 the DoD produced another revision called Ironman, and contracted four vendors to develop preliminary languages based on

Ada helps build automobiles at a Citroën plant in France. An Ada development system from Alslys helps the auto manufacturer create simulators for robotic assembly equipment.





Certain Ada development systems run on workstations instead of minicomputers. This Telegen2 cross-development system from TeleSoft operates in the windowed environment of a Sun 3 workstation from Sun Microsystems.

this refined set of requirements.

The resulting four languages were color coded (blue, green, red, and yellow) to disguise the developers. The DoD then distributed the four languages to interested parties for review. Two of the languages (red and green) survived this review, and their respective developers (Intermetrics of Cambridge, MA and Cii-Honeywell Bull of France) worked to refine their languages against a final specification called Steelman. The refined versions of the two languages competed, again through review, and the DoD selected the language from Cii-Honeywell Bull as the final version of Ada. Thus Ada evolved through competitive design; it wasn't patched together by a committee of pie-in-the-sky academics. The final design decisions were made by either Dr Jean Ichbiah (who later founded Ada-compiler vendor Alsys) or his hand-picked assistants.

MYTH: Ada is too big to learn and too unwieldy to use. The entire Ada language encompasses only 63 reserved words (Table 2)—a fairly small number compared with a more widespread and less-feared language such as Microsoft Basic, which comprises some 200 commands, statements, and functions. Ada's power is derived from its flexible use of these few key words. Although 63 reserved words may not qualify Ada as a reduced-instruction-set, high-level language, this small number of words undermines the myth that Ada is too big to learn.

Conversely, Ada provides tremendous flexibility for

using these reserved words, so proficient use of the language does require a fair amount of study. Also, Ada incorporates a few unfamiliar concepts, such as tasking and separately compiled program units, that require you to make certain mental adjustments.

The compilers must accommodate every Ada feature, but few programmers use every facet of any programming language. Therefore, you don't have to learn all of Ada's nuances before you can begin using it. In this sense, Ada is no more difficult to use than other programming languages. As with any development tool, if you want to use the novel features of the language, you'll have to study them. Many programmers have already used Ada successfully to produce very large and complex systems.

MYTH: Ada is too slow to use for real-time applications. This myth has a factual basis; early Ada compilers were indeed too slow for many real-time requirements. However, "too slow" is a relative term, because some electromechanical systems define system speeds in tens or hundreds of milliseconds, and other systems require microsecond response times. At a certain point, any programming language becomes too slow to meet the application requirements. Most Ada users acknowledge that the performance problems that once existed have largely disappeared over the last two years, as the compilers have matured. Improved optimization schemes (see **box**, "Compilers optimize Ada for speed"), faster runtime executives, and alternative interrupt mechanisms have been key factors in boosting Ada's real-time performance.

MYTH: Ada stunts a programmer's creativity be-

TABLE 2—ADA's RESERVED WORDS

ABORT	EXCEPTION	PRIVATE
ABS	EXIT	PROCURE
ACCEPT	FOR	RAISE
ACCESS	FUNCTION	RANGE
ALL	GENERIC	RECORD
AND	GOTO	REM
ARRAY	IF	RENAMES
AT	IN	RETURN
BEGIN	IS	REVERSE
BODY	LIMITED	SELECT
CASE	LOOP	SEPARATE
CONSTANT	MOD	SUBTYPE
DECLARE	NEW	TASK
DELAY	NOT	TERMINATE
DELTA	NULL	THEN
DIGITS	OF	TYPE
DO	OR	USE
ELSE	OTHERS	WHEN
ELSIF	OUT	WHILE
END	PACKAGE	WITH
ENTRY	PRAGMA	XOR

To objectively evaluate Ada as a development tool for your next real-time project, you must first shed some myths that have grown around the language.

cause it enforces a rigid programming style. This notion is true only if sloppy work, sneaky programming tricks, and incomplete documentation pass for creativity. Ada enforces software engineering concepts such as code and data abstraction, documentation, and modularity. These characteristics are absolutely required for large programming projects that span several months or years and involve many programmers. When people leave their jobs, others can continue the work easily if the programs are written using a structured tool such as Ada.

Taking the longer view, a well-constructed (engineered) program makes it easier and more economical to maintain software over a long product life (a prime concern of the DoD), and it allows a programmer to make program improvements and additions years after the original author has gone. Archaic programming styles make software maintenance and enhancement impossible. Nevertheless, many companies perpetuate the use of software that is decades old, simply because no one knows how the programs work anymore, and no programmer dares to touch the golden code in case

Compilers optimize Ada for speed

Compilers must generate fast code if Ada is to be a viable language for real-time embedded systems. Optimizations can make or break a compiler's suitability for such applications. Although compilers can create very inefficient assembly-language code, the compiler's optimizer relentlessly applies a large number of optimization techniques that can tremendously reduce the inefficient assembly language generated by the compiler. Consequently, compiler vendors are applying a long list of optimization techniques to the problem of speeding up and slimming down programs written in Ada. Several of these techniques are listed in Table A.

Because Ada's programming style emphasizes modularity, Ada programs tend to incorporate many subprograms and subroutines. However, in-line code runs faster than code that calls subroutines. Subroutines called only once can be safely placed in line. This step eliminates subroutine-call overhead and return-address storage, and it reduces both program storage space and program execution time. A com-

piled program may automatically generate in-line subroutine calls, or you may invoke in-line code through Ada's "inline" pragma. If the subroutine is used several times within the program, the insertion of in-line code may increase storage requirements, but the pro-

gram will still run faster.

Careful use of CPU registers also allows a program to run faster. Registers provide faster access to program variables than do RAM locations. A technique called graph coloring lets an optimizer evaluate variable usage

TABLE A—COMPILER OPTIMIZATION TECHNIQUES

- IN-LINE CODING OF SUBROUTINE CALLS
- REGISTER UTILIZATION
 - GRAPH COLORING
 - BASE REGISTER ALLOCATION
- PEEPHOLE OPTIMIZATION
- STACK ALLOCATION
- CONSTANT EVALUATION
- LOOP OPTIMIZATION
 - LOOP INVARIANTS
 - LOOP INTERCHANGE
 - LOOP FUSION
 - LOOP EXPANSION
- CONSTRAINT ELIMINATION
- COMPILE-TIME EVALUATION OF CONSTRAINTS
- ALGEBRAIC SIMPLIFICATION
- EXPRESSION ORDER
- BRANCH ELIMINATION
- DEAD CODE ELIMINATION
- LIBRARY OPTIMIZATION
- DEAD VARIABLE ELIMINATION
- INTER-UNIT OPTIMIZATION
- GENERIC SHARING
- CONSTANT PROPAGATION
- LITERAL POOLING
- STRENGTH REDUCTION
- COMMON SUBEXPRESSION ELIMINATION
- TEST MERGING
- BOOLEAN EXPRESSION
 - OPTIMIZATION
 - DEMORGANS
 - PACKING
- STATIC ELABORATION

a programming error causes an accident. Ada alone can't change this unfortunate situation, but the language's structure helps you create an environment for engineered program development.

Ada promotes software engineering over hacking

Ada is a structured programming language, which primarily means that programs written in Ada make liberal use of "begin" and "end" statements. Structured programming isn't new, but it is a cornerstone of software engineering. Moreover, Ada's features also sup-



Graphic development tools for Ada programs, such as this directed-graph editor and code generator developed by the Westinghouse Electronic Systems Group (Baltimore, MD), drastically reduce the apparent complexity of an embedded design and clarify the various subunits within a program.

and assign the most frequently used variables to registers. Similarly, peephole optimization eliminates superfluous loads, stores, and comparisons when the desired information is already available in a register. Often, peephole optimizers recognize common code sequences that are frequently generated by the compiler and replace these sequences with prepared code sequences that have been specially engineered to run faster.

Loop optimizations also speed program execution by moving as much code as possible out of the loop. Although you should always strive to keep as much code out of a loop as possible, an optimizer may compress even lean loops by pushing some of the assembly language emitted by the compiler's code generator outside of the loop. Short loops can be unrolled into in-line code to save execution time at the expense of code size. You can invoke such an optimization by using Ada's "optimize (Time)" pragma.

Ada programs spend a lot of time performing constraint checks; it's one of the features that supports software engineer-

ing. However, constraint-checking routines can consume as much as 40% of a program's execution time. Some compilers detect certain constraint violations, such as illegal variable assignments, at compile time rather than postponing the discovery until runtime. This technique eliminates constraint-checking code from the runtime program and speeds the program's execution. Compilers can also evaluate constants, as well as expressions that compute values based on constants, at compile time. This feature saves code space and execution time. Some compilers can evaluate such expressions across separately compiled program units for even greater efficiency.

Many constraint checks can be eliminated without removing the safety net provided by the checks. For example, a program doesn't need to check constraints inside a loop if the loop parameters make the generation of an exception impossible. Thus, one constraint check at the start of the loop may suffice. In addition, Ada programs run much faster if you disable constraint-checking routines. You may be able to per-

manently disable constraint checking if your software testing has ensured that constraint violations aren't possible. Ada's "suppress" pragma lets you tell the compiler to omit certain types of constraint checking.

The optimizer can also speed a program's computations. Algebraic simplification or the application of deMorgan's theory often allow a compiler to reduce the strength of a computation by substituting a simple operation for a complex one. For example, a compiler might replace an operation that raises a variable to the second power with an expression that multiplies the variable by itself. Similarly, multiplication can often be replaced with addition ($2 * X = X + X$). Boolean arrays can be packed so that logical operations occur a word at a time instead of a bit at a time. In some cases, this optimization can even reduce a loop to one instruction.

Reference

Gilinsky, Richard J and Sabina H Saib, "Design for High Performance," Proprietary Software Systems, Santa Monica, CA.

Even though the compilers must accommodate every Ada feature, few programmers use every facet of any programming language.

port the following software-engineering concepts:

- Top-down development
- Strong data typing
- Abstraction (data and actions)
- Information hiding and encapsulation
- Separation of specification from implementation
- Reusability
- Separation of physical realization from logical concepts
- Portability
- Modularity
- Readability.

Ada supports top-down program development through program subunits called "packages." A package delivers the capabilities of subprograms contained within the package to other portions of the program without revealing the inner details of those subprograms. In fact, packages can be compiled separately at different times, and the Ada compiler confirms that subprograms from another part of the program call a package's subprogram properly, by using the right number of parameters and the correct data types. Because only the package's interface is visible to the rest of the program, the overall program structure can be created without worrying about the detailed design of each package. Separate compilation of a package's interface specifications and its code body lets you create a high-level program design and construct the necessary packages, postponing the packages' implementation details until later.

Strong data typing helps an Ada compiler ensure that the interfaces between two program units match, even if those units are separately compiled. Ada doesn't even let you add two integers unless they have the same precision. This feature prevents inadvertent mixing of data types and forces you to make all type conversions explicit, a rule that makes Ada code easier to maintain over the years. Consequently, you must declare a data type for every variable you use in an Ada program. The compiler won't provide you with default data types.

Abstraction allows you to hide the details of a program unit inside of the unit and provide a public description of the unit's function. Ada has two mechanisms for abstracting a program unit's actions: subprograms (functions and procedures) and packages. Ada's subprograms are not substantially different from the equivalent entities in other programming languages. However, packages and generics are novel Ada constructs. A package can contain any combination of data



Robotic parts carriers driven by Ada programs in a new factory in Sweden help Volvo build automobiles. (Courtesy TeleSoft)

types, descriptions, functions, and procedures. The Ada package lets you create a set of functions that operate on a special data type, such as complex numbers, that you define within the package. Ada's packages encourage you to create reusable code modules; the language's separate-compilation feature further enhances that programming style. Ada packages are essentially software components, and a business has sprung up in the Ada domain to create and market collections of independently developed Ada packages (statistics, thermal analysis, graphics, etc).

Generics create software templates

The generic package, or generic, takes the concepts of the Ada package one step further. A generic is a parameterized package that serves as a template for other modules. For example, you might create a stack package that knows how to create and manage stacks in memory. Without the generic, you'd need different packages to handle integer, floating-point, and character stacks. But the generic lets you create one generic package and then instantiate that package by using parameters to define the data type to be stored on the stack.

The Ada package also supports encapsulation and information hiding. These two characteristics help to keep a programmer's assumptions valid. Because Ada is designed to support multimillion-line programs, the strong protection mechanisms of encapsulation and information hiding are critical features of the language.

Encapsulation lets you gather information into a module and allow access to this information only in well-defined ways. The rest of your program cannot manipulate these encapsulated values except through the package calls you create. Without encapsulation, a module in a remote portion of a program might tinker with a package's critical values and cause the package

to generate erroneous results. Thus, encapsulation preserves the package programmer's assumptions regarding data integrity within the package.

The second protection mechanism, information hiding, prevents other program units from using intermediate values that are generated within the package. Without this feature, a remote portion of a program might use intermediate values that might not exist in the next package revision. Thus, information hiding prevents the creator of that remote piece of code from making assumptions about values in a package.

Ada packages also let you separate a module's specification from its implementation and compile them separately. This ability encourages top-down design because it lets you create and compile the module's specification as part of the high-level design process, and then return to the module later to complete the detailed coding. In addition, Ada packages promote reusability by forcing a programmer to document the package's interface in the specification.

Coupling to the physical machine

To promote portability, Ada's designers tried to create a language that is not specific to any machine. However, every program must eventually address the special characteristics of the machine running the software. In the form of representation specifications ("rep specs") and pragmas, Ada provides a bridge between the logical machine and the physical machine. Rep specs let you create special data types whose structures exactly match the physical machine's data structures. Thus, you can map your hardware's I/O registers and memory locations into Ada variables once through a rep spec, and then use the physical bits of the machine as logical variables throughout the rest of your program. Pragmas are compiler directives that can direct a compiler to make specific associations between Ada structures and the physical machine.

If the entire link between the Ada program and the physical machine exists through rep specs and pragmas, then the rest of the program is portable across a range of computing hardware. However, you don't get portability simply by using Ada to write programs. Ada provides the tools required to build portability into a program, but you'll still need to discipline yourself to confine machine-specific code to well-defined modules.

You can create nonmodular code with Ada if you work at it, but Ada clearly encourages a modular coding style. In addition, the language's requirement that

you declare everything, including a package's interface specifications, enhances the readability of Ada programs. A determined programmer can use any language to write unreadable code, so a few rules for programming style are helpful.

Ada's language features make it an excellent choice for creating large programs, but Ada's specification also incorporates several aspects of a real-time, operating-system (OS) executive to enhance its use in developing embedded systems. The Ada runtime environment appears in **Fig 2** as classified by ARTEWG (the Ada Runtime Environment Working Group, sponsored by ACM SIGAda—the Ada special-interest group of the Association for Computing Machinery). The Ada runtime environment incorporates components that activate and terminate tasks, manage memory and I/O functions, keep track of time, and handle interrupts.

When you are choosing among competing Ada compilers for real-time application development, one of the first choices you must make is the type of runtime executive you want. You have three choices: First, you can pick an Ada development system that integrates a real-time executive written by the compiler vendor into the compiler's runtime library. Second, you can pick a development system that has been married to a commercial runtime kernel. Your third choice is writing your own real-time executive in Ada, assembly code, or another programming language.

Built-in Ada real-time executives employ Ada's tasking model to manage multiple tasks, using a priority scheme to schedule task execution. Ada's priority pragma lets you associate each task with a fixed prior-

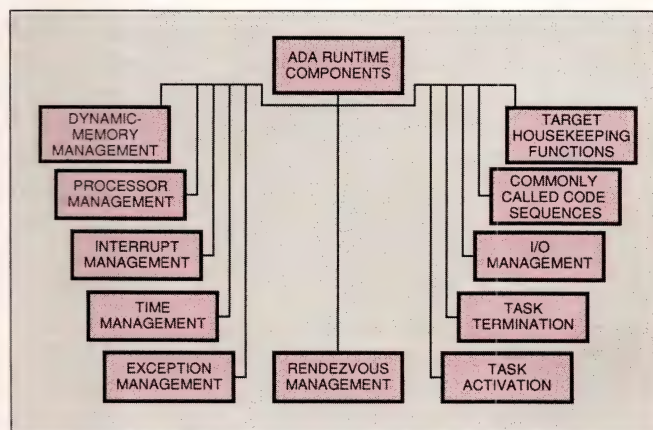


Fig 2—Ada's runtime environment manages several hardware resources and also is responsible for task management. This classification was created by ARTEWG, the Ada Runtime Environment Working Group of ACM's SIGAda.

Ada is a structured programming language, which primarily means that programs written in Ada make liberal use of the "begin" and "end" statements.

ity. That priority tells the scheduler which task to run if two or more tasks become unblocked at the same time. Tasks become blocked when waiting for a rendezvous (see **box**, "Synchronizing tasks through Ada's rendezvous"), when waiting for an Ada "delay" statement to expire, or when waiting for a dependent task to complete its execution.

The priority pragma can cause problems for real-time systems, because it permits only static (fixed) task priorities. Thus, if you have a mode-dependent system with tasks that vary in importance over time, the priority pragma won't let you change a task's priority to accommodate the mode shift. In addition, a task's priority, as assigned by the priority pragma, doesn't determine which task is chosen by a task server. Ada's specification requires server tasks to satisfy requests from other Ada tasks in FIFO order, ignoring task priority.

An Ada server task doesn't inherit the priority of the task it runs, and this characteristic may lead to priority inversion. During priority inversion, a lower-

priority task pre-empts a higher-priority task. Because an Ada server doesn't inherit the priority of the task it's serving, it essentially transforms the priority of the task it's currently serving to the server's priority. For example, assume that an Ada program contains three tasks: task 1 with a priority of 20 (the larger the number, the higher the priority), task 2 with a priority of 18, and a server task with a priority of 15. If task 1 requests service from the server task, then task 1 effectively assumes a priority of 15 when the server task is satisfying task 1's request. During that time, task 2 can pre-empt the server task, thus pre-empting task 1, even though task 1 has the highest priority.

Runtime extensions increase efficiency

To compensate for these inadequacies of Ada's priority scheme, some Ada development-system vendors have created extensions to their runtime executives that allow Ada programs to work more efficiently in real-time applications. For example, DDC-I's runtime system lets you assign dynamic task priorities. It pro-

Synchronizing tasks through Ada's rendezvous

Ada allows you to break your program into multiple subprograms called tasks. These tasks are logically independent and can run concurrently. If you can divide your program into truly independent tasks, you need nothing more from the language. However, you often need a mechanism that allows tasks to cooperate by communicating and synchronizing with each other. Ada provides such a mechanism in its romantically named "rendezvous." The basic rendezvous process governs the interaction between a calling task and the called task.

An Ada task that wishes to send information to another task uses an "entry" statement to call the other task. The called task indicates its desire to receive information through an "accept" statement. If the calling task exe-

cutes its entry statement first, it becomes blocked and stops executing until the called task executes its accept statement. Conversely, if the called task executes its accept statement before the calling task executes its entry call (a situation made possible by the tasks' concurrent execution), the called task becomes blocked and stops executing until the calling task executes the entry call. This process is the basic rendezvous mechanism, and it allows two tasks to synchronize by blocking one task until the other task reaches the rendezvous point.

You can also use the rendezvous mechanism to exchange information between the tasks through parameter passing. Parameters may be unidirectional, allowing one task to send infor-

mation to another, or bidirectional, allowing the tasks to interchange information in both directions. The act of passing information between the tasks also synchronizes them.

Finally, you can create a task that will rendezvous with several other tasks by using the "select" statement to group several accept statements together. The select statement prevents the task from becoming blocked when the first accept statement is executed. Instead, the task becomes blocked by all of the accept statements defined within the select-statement block, and the task accepts the first entry call that arrives from any of the tasks involved in the rendezvous. Task servers use the select statement to rendezvous multiple client tasks.

HOW TO BE A RISC TAKER WITHOUT BEING A DAREDEVIL.

Take the Motorola 88000 RISC* microprocessor.

It's being supported by a complete array of business software. For applications like office automation, desktop publishing, word processing, database management, spreadsheets and MS/DOS-compatible software. And the list is growing.

Thanks largely to the efforts of the 88open, a consortium of over 50 leading hardware and software vendors devoted to making the 88000 the RISC microprocessor standard.

The 88open has developed a Binary Compatibility Standard (BCS) that guarantees a standard software design environment



for the 88000. So, in the same way that MS/DOS* software runs on any PC, any software written for one 88000-based machine runs seamlessly on every 88000-based BCS-compliant system.

What's more, since AT&T has endorsed the 88000 BCS as the early development platform for their UNIX System V.4 ABI, the 88000 is the fastest way to get to tomorrow's UNIX V.4.

For more information, contact your Motorola sales office.

It's not only the greatest RISC you can take.
It's the safest.

Winner 1988



MOTOROLA

*Reduced Instruction Set Computer.

© 1989, Motorola Inc. All names indicated by TM or ® are trademarks or registered trademarks of their respective holders.

Ada doesn't allow you to add two integers unless they have the same precision.

motes a server task's priority to the maximum of the server task's or the served task's priority, thus preventing priority inversions.

As designers continue to use Ada for a variety of projects, the features that the language needs to support real-time systems become more apparent. The ARTEWG has developed a Catalog of Interface Features and Options (CIFO) for Ada runtime environments, to promote a standard method for adding proposed real-time extensions to the language through packages and pragmas. The CIFO contains entries for features such as special delays, task identifiers, interrupt management, and fast-interrupt pragmas.

Fast interrupts cut overhead

The need for a fast-interrupt mechanism arises because Ada's conventional interrupt mechanism links an interrupt to an Ada task through the rendezvous mechanism (see **box**, "Synchronizing tasks through Ada's rendezvous"). Standard Ada tasks accept entry calls from other tasks in the program and incur a tremendous amount of overhead as the program's data structures are read and updated to preserve system state. The overhead of a rendezvous makes the conventional Ada interrupt mechanism too slow to be used for most real-time applications.

A fast-interrupt pragma labels the associated task as a fast-interrupt task and exempts that task from bookkeeping overhead. However, a fast-interrupt task must meet certain restrictions. First, the fast-interrupt task must use no more than a predefined amount of stack space. Also, the interrupt task's code must be straightforward and can't contain time-consuming statements such as delays or entry calls to other tasks. Finally, other program tasks can't call the fast-inter-

rupt task—only the interrupt may activate this task. Fast interrupts can cut an interrupt-service routine's activation overhead by 50%.

Commercial runtime packages offer alternatives

In most cases, you can use a built-in runtime executive when Ada's tasking model works for your application. However, many designers of real-time systems are accustomed to other tasking models and prefer alternative communications mechanisms, such as semaphores. If you fit into this category, you may prefer to use a hybrid development tool that teams an Ada compiler with a standard, commercial runtime package. Several Ada packages incorporate real-time kernels from vendors such as Ready Systems, Industrial Programming Inc (Jericho, NY), and Wind River Systems (Emeryville, CA).

The RTAda packages from Ready Systems combine TeleSoft Ada compilers with ARTX, an enhanced version of the Ready Systems VRTX32 runtime kernel. ARTX incorporates the services needed to manage Ada tasks (create, delete, suspend, resume, and assign priority); a time-slicing (round-robin) scheduler; character I/O routines; timekeeping; interrupt services; memory allocation; and intertask communications services. If you have used Ready Systems' OS kernel in the past, ARTX's compatibility with VRTX32 makes it easier to convert programs written in C or assembly language, because the kernel calls don't change. This compatibility lets you incrementally convert previously written programs when time allows, or when you need to enhance an existing program.

Commercial real-time kernels such as ARTX give you explicit control over task scheduling. You can create, destroy, suspend, and resume tasks by using calls

How to get Ada aid

Tackling Ada is a very big project, but fortunately help is available. Several sources provide you with substantial amounts of information, often for free. The DoD operates the Ada Information Clearinghouse, which publishes a quarterly newsletter. For more information, write to AdaIC, Room 3D139, The Pentagon,

Washington, DC, 20301, or call (703) 685-1477. You can also receive information from the AdaIC's computerized bulletin board by calling (202) 694-0215 or (301) 459-3865. The ACM sponsors the SIGAda users group, which publishes *Ada Letters*, a bi-monthly newsletter; contact Dr Ben Brosgol at Alslys Inc. In addition,

ACM SIGAda will sponsor the TRI-Ada conference at the Software Engineering Institute in Pittsburgh, PA, on October 23-26, 1989. This year, TRI-Ada will focus on real-world Ada applications. For further information, contact John Foreman at (412) 268-6217, or Charles B Engle, Jr at (412) 268-6525.

It's a trap.

Trap tricky hardware and software bugs,
... precisely.

Powerful debug commands aren't worth much if they're too difficult to use. We've designed the SA98 to trap bugs based on simple, well defined, and detailed commands.

Quick Change Artistry

No more running up and down command trees to change or modify an emulator condition. Change commands without stopping the emulator. Define in-depth breakpoints. Call up help menus and files as you need them. And you can go from 8- to 32-bit microprocessors quickly.

You Set the Rules

Define your own soft keys and macro commands. With the PC/AT or XT function keys configured for emulation functions, you can type in and modify commands directly.

Powerful Commands

The SA98 command structure is so powerful and precise, comparing it to other systems is tough on them. Let the power of the SA98 trap your toughest problems and break out of conventional traps.

More Than Expected

Call for a demonstration, and see how good a trap it really is. You'll see fast, well defined solutions.

**Sophia
systems™**

Dedicated to MDS/ICE Support

European Headquarters:

Sophia Computer Systems, Ltd.
Alpha House
London Road, Bracknell
Berkshire RG12 2TJ, England
Tel: 0344-862404
Fax: 0344-861374

United States: Tel: 408-733-1571
Telex: 853394

France: Tel: 74 43 8045

Sweden: Tel: 08-754 93 00

Italy: Tel: 11-746769

Corporate Headquarters:

Sophia Systems Co., Ltd.
NS Bldg 8F
2-4-1 Nishishinjuku, Shinjuku-ku
Tokyo 163 Japan

©1988 Sophia Systems

Sophia Systems is a registered trademark of
Sophia Systems Co., Ltd.

ICE is a registered trademark of Intel Corporation.

MDS is a registered trademark of
Mohawk Data Science Corporation.

IBM PC/AT and XT are registered trademarks
of International Business Machines Corporation.

Encapsulation preserves the package programmer's assumptions.

to the kernel. Although Ada's rendezvous mechanism also provides this control, it relies on the interaction of two or more tasks. In addition, commercial real-time kernels give you several types of intertask-communication links, including mailboxes, binary event flags, queues, and semaphores, instead of Ada's single technique of passing parameters between tasks. These additional links let you tailor intertask communications by using the most efficient communications technique for your situation.

Unfortunately, you must accept a loss of portability when you use the extended services of a commercial real-time kernel. If you use these extensions, and then later move your program to another processor (using a different compiler), the runtime environment will be different, and those extended services may no longer be available. In that case, you would be forced to rewrite small or even large portions of your software.

You have another alternative if you need to extend Ada's runtime capabilities: You can write those extensions in Ada as part of your program. For example, if you need semaphores, you can write an Ada package that implements semaphores. Similarly, you can write your own task scheduler in Ada if you don't like Ada's priority scheme. Thus, if your application calls for a cyclic executive, you can write one in Ada as part of your program. Using Ada's own capabilities to extend the language lets you maintain portability across compilers and processors. However, the resulting code might be too slow for your application.

Fortunately, higher speed is the real-time Ada vendor's Holy Grail. These vendors realize that Ada won't become a widespread language unless the resulting code can run as fast as code generated with other programming languages. The common perception is that Ada is an inherently large and slow language when compared with a "fast and dirty" language such as C. However, several Ada-compiler vendors claim that the optimized code generated by their products can run as fast, or faster, than code generated by C compilers (Fig 3).

Benchmarks may be helpful

When you start to compare the code generated by different development systems, you immediately descend into the gray world of benchmarks. Ada compilers must be validated before they can bear the name "Ada," but validation gives you no indication of performance. The Ada community has created many

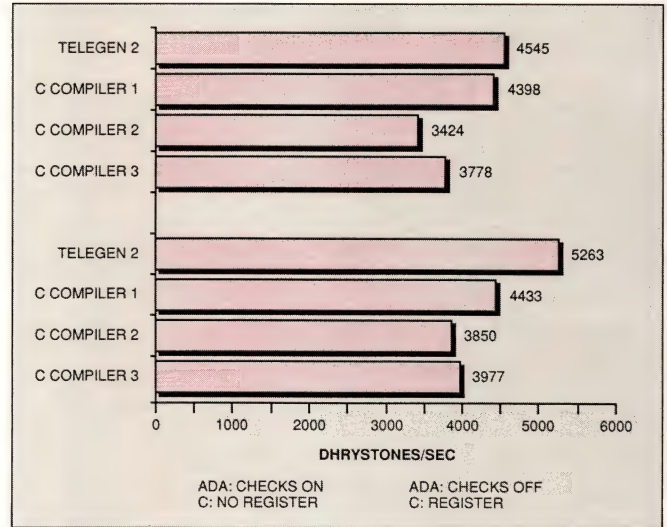


Fig 3—As compiler technology has improved, Ada vendors are comparing the speed of their products to other languages known for their speed. For example, TeleSoft's Ada compiler for the Motorola 68000 μ P family can exceed the performance of C compilers in the Dhrystone benchmark.

benchmark program suites that test compiler performance. Some benchmarks employ large programs to test the overall efficiency of a compiler, and other benchmark test suites use several small programs to focus on the performance of individual Ada features.

Some of the principal Ada benchmark test suites include the US government's Ada Compiler Evaluation Capability (ACEC); the PIWG (Performance Issues Working Group of ACM SIGAda, pronounced "pie-wig") benchmarks; the British government's Ada Evaluation System (AES); and various benchmark programs stored in the Ada Software Repository.

The ACEC test suite comprises 240 programs that perform more than 1000 tests. These tests focus on execution performance of the code generated by the compiler, and they also measure compile time and code size. The ACEC test suite is available to qualified DoD contractors from the Data Analysis Center for Software (Griffiss AFB, NY).

The PIWG constructed and maintains a suite of benchmark programs in the public domain. (For more information on the PIWG, contact Rob Spray, PIWG Tree, Box 850236, Richardson, TX.) The PIWG programs test the performance of Ada features such as clock resolution; task creation and rendezvous times; dynamic storage allocation; exception handling speed; procedure-call and constraint-checking overhead; and compilation speed. Many Ada-development-system

**Now \$18,000 will
put the best on
your bench: the
DAS 9200.**

32-bit MICRO SUPPORT

32 K

**BITS OF MEMORY
DEPTH**

Current	Seq	Address	Data	Hexmatics	Disas. Support
Current	Sequence	Address	Data	Hexmatics	Disas. Support Time/loop
532	net_intra24	D0006660	00000000	MOV EBX, 0	1.158 µs
	net_intra20	D0006660	00000000	JNZ EBX, 0	
	net_intra24	D0006660	00000000	MOV EBX, EBX	
532	net_intra20	0065F000	00000000	MOV EBX, 0	1.26 ns
	net_intra20	0065F000	00000000	JNZ EBX, 0	
534	net_intra20C	00001010	00000000	MOV EBX, 0	1.26 ns
	net_intra20C	00001010	00000000	JNZ EBX, 0	
535	net_intra20	0F30A000	00000000	MOV EBX, 0	1.40 ns
	net_intra20	0F30A000	00000000	JNZ EBX, 0	
536	net_intra34	57000000	00000000	MOV EBX, 0	1.28 ns

Current	Seq	Address	Data	Hexmatics	Disas. Support
Current	Sequence	Address	Data	Hexmatics	Disas. Support Time/loop
Group Value:	Pos_4C	00			

Timing diagram showing clock and data signals. The clock signal is a regular square wave. The data signal is a red line that stays at 0 until approximately 10 ns, then jumps to 1 and stays there until approximately 25 ns, then jumps back to 0. The diagram is labeled with 'Clock (100ns)' and 'Data'.

Current	Seq	Address	Data	Hexmatics	Disas. Support
Current	Sequence	Address	Data	Hexmatics	Disas. Support Time/loop
Group Value:	Pos_4C	00			

Timing diagram showing clock and data signals. The clock signal is a regular square wave. The data signal is a red line that stays at 0 until approximately 10 ns, then jumps to 1 and stays there until approximately 25 ns, then jumps back to 0. The diagram is labeled with 'Clock (100ns)' and 'Data'.

90 CHANNELS

Performance analysis, disassembly, signal passing, color display, pop-up menus, impressive new

Stop hankering after the DAS 9200, and get your hands on it at last. For information or a demonstration, contact your Tek sales engineer, or call 1-800-245-2036. In Oregon, 231-1220.



117

Ada's definition also incorporates several aspects of a real-time, operating-system executive to enhance its use in developing embedded systems.

vendors provide the results of the PIWG benchmarks if you ask for them, but be careful not to make faulty comparisons; the benchmarks are run on a wide variety of processor architectures at differing clock speeds and with different memory wait states. These hardware differences can mask variations in compiler performance.

The British government developed the AES test suite in 1987 to measure compile- and execution-time

performance, the quality of the generated code, the quality of the error and warning messages generated at compile time, and the capabilities of the Ada development system's debugger. The AES is distributed by the Information Technology Department of the British Standards Institute (Milton Keynes, UK).

The Ada Software Repository resides on a computer in the Defense Data Network. It is accessible to many DoD contractors and to certain universities through

Manufacturers of real-time Ada development systems

For more information on real-time Ada development systems such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Aetech Inc
380 Stevens Ave
Solana Beach, CA 92075
(619) 755-1277
Circle No 650

Aitech Systems Ltd
1250 Oakmead Pkwy, Suite 210
Sunnyvale, CA 94086
(408) 720-9400
Circle No 651

Alslys Inc
67 S Bedford St
Burlington, MA 01803
(617) 270-0030
FAX 617-270-6882
Circle No 652

BiiN
2111 NE 25th Ave
Hillsboro, OR 97124
(503) 696-4800
TLX 707351
Circle No 653

DDC-I Inc
Box 37767
Phoenix, AZ 85069
(602) 944-1883
Circle No 654

Harris Computer Systems
2101 W Cypress Creek Rd
Fort Lauderdale, FL 33309
(305) 974-1700
Circle No 655

Intel Corp
5200 NE Elam Young Pkwy
Hillsboro, OR 97124
(503) 640-7147
Circle No 656

Interact Corp
136 Madison Ave
New York, NY 10016
(212) 696-3785
Circle No 657

Intermetrics
33 Concord Ave
Cambridge, MA 02138
(617) 661-1840
Circle No 658

Irvine Compiler Corp
18021 Sky Park Circle, Suite L
Irvine, CA 92714
(714) 250-1366
Circle No 659

Loral/ROLM MIL SPEC
1 River Oaks Pl
San Jose, CA 95134
(408) 432-7933
Circle No 660

Meridian Software Systems Inc
23141 Verdugo Dr
Suite 105
Laguna Hills, CA 92653
(714) 380-9800
Circle No 661

Microware Systems Corp
1900 NW 114th St
Des Moines, IA 50322
(515) 224-1929
Circle No 662

MIPS Computer Systems Inc
928 Arques Ave
Sunnyvale, CA 94086
(408) 720-1700
TWX 510-601-5346
Circle No 663

National Semiconductor Corp
Box 58090
Santa Clara, CA 95052
(408) 721-5000
TWX 910-339-9240
Circle No 664

Proprietary Software Systems
429 Santa Monica Blvd
Santa Monica, CA 90401
(213) 394-5233
Circle No 665

Rational
3320 Scott Blvd
Santa Clara, CA 95054
(408) 496-3600
FAX 408-496-3636
Circle No 666

Ready Systems
Box 60217
Sunnyvale, CA 94086
(408) 736-2600
FAX 408-736-3400
Circle No 667

Rockwell International
Collins Div
400 Collins Rd NE
Cedar Rapids, IA 52498
(319) 395-1000
Circle No 668

RR Software Inc
2317 International Lane, #212
Madison, WI 53704
(608) 244-6436
TLX 4998168
Circle No 669

Systems Designers Software Inc
101 Main St
Cambridge, MA 02142
(617) 499-2000
Circle No 670

SofTech Inc
460 Totten Pond Rd
Waltham, MA 02154
(617) 890-6900
Circle No 671

Tartan Laboratories Inc
461 Melwood Ave
Pittsburgh, PA 15213
(412) 621-2210
Circle No 672

TeleSoft
5959 Cornerstone Ct W
San Diego, CA 92121
(619) 457-2700
FAX 619-452-1334
Circle No 673

TLD Systems Ltd
21235 Hawthorne Blvd, Suite 204
Torrance, CA 90503
(213) 316-1516
Circle No 674

Verdix Corp
14130-A Sullyfield Circle
Chantilly, VA 22021
(703) 378-7600
Circle No 675



Here's something that will help everyone sleep better. Except our competition.

At UPS, we have something that will help assure you a restful night's sleep when it comes to overnight delivery.

It's guaranteed UPS Next Day Air.*

For some time UPS has been the only company fast and reliable enough to deliver overnight to every single address coast to coast. And we guarantee it, or you don't pay for it.

What's more, we'll even guarantee delivery in

the morning to the vast majority of people across the country.

And because of our efficiency, we're still able to do all of this for up to half what other companies charge.

All of which is guaranteed to give our competition a restless night's sleep.

And you a comfortable one.

We run the tightest ship in the shipping business.



*See our current Next Day Air Service Explanation and Air Service Guide for complete guarantee details.

NEW! SWITCHMODE POWER SUPPLIES FROM STOCK

- 2 to 48 VDC Outputs
- Automatic Current Sharing On All Outputs
- N+1 Capabilities



MULTIPLE OUTPUT



- 350 to 1500 Watts
- 3 to 15 Outputs

SINGLE OUTPUT



- 400 to 3000 Watts in 5" x 8" Standard Package
- 155,000 Hrs. Demonstrated MTBF

Hot Plug-In FAULT TOLERANT (N+1) POWER SYSTEMS



- Two to Six Supplies
- Expandable, 300 to 1800 Watts
- Internal Isolation Diodes (Option)

POWERTEC

The Power in Power Supplies

20550 Nordhoff Street Chatsworth, CA 91311
(818) 882-0004 • FAX (818) 998-4225

CIRCLE NO 69

the Arpanet network. The repository contains source code, software components (packages), and educational material to support Ada development efforts, and it holds many benchmark test suites, including the PIWG programs.

For nearly a decade, the DoD and a sizable number of government contractors and software developers have pushed the development of Ada along the path to maturity. It is a fortuitous coincidence that Ada has ripened at about the same time that many engineers have started to use 32-bit μ Ps for real-time embedded systems. Hacking a few million lines of code is a contradiction in terms, and systems based on 32-bit processors can no longer be programmed in the style of their predecessors. For big programming jobs, you should consider Ada.

EDN

References

1. Borger, Mark, Mark Klein, and Robert Veltre, "Engineering Real-Time Software in Ada: Observations and Guidelines," Software Engineering Institute, Pittsburgh, PA, March 1989.
2. Cohen, Norman H, *Ada as a Second Language*, McGraw-Hill Book Co, New York, NY, 1986.
3. Crafts, Ralph E, "The Software Development Integrity Program (SDIP)," Ada Strategies, June 1988, pg 8.
4. Lieblein, Edward, "The Department of Defense software initiative—a status report," Communications of the ACM, August 1986, pg 734.
5. Nielsen, Kjell and Ken Shumate, *Designing Large Real-Time Systems with Ada*, Intertext Publications/Multiscience Press Inc, McGraw-Hill Book Co, New York, NY, 1988.
6. Ripps, David L, *An Implementation Guide to Real-Time Programming*, Prentice-Hall Inc, Englewood Cliffs, NJ, to be published in 1990.
7. Sammet, Jean E, "Why Ada is not just another programming language," Communications of the ACM, August 1986, pg 722.
8. Small, Charles H, "Real-time operating systems," EDN, January 7, 1988, pg 114.
9. Weiderman, Nelson H, "Ada Adoption Handbook: Compiler Evaluation and Selection," Technical Report CMU/SEI-89-TR-13, Software Engineering Institute, Pittsburgh, PA, March 1989.
10. "A Catalog of Interface Features and Options for the Ada Runtime Environment," Association for Computing Machinery, Special Interest Group for Ada, December 1987.
11. "Status, Costs, and Issues Associated With Defense's Implementation of Ada," GAO/IMTEC-89-9, United States Government Accounting Office, Washington, DC, 1989.

Article Interest Quotient (Circle One)
High 500 Medium 501 Low 502

Clean Power!

10 V/cm

VI-200™
DC-DC Converter
4.6"L x 2.4"W x 0.5"H

VI-RAM™
Ripple Attenuator Module
2.28"L x 2.4"W x 0.5"H

2 mV/cm

If Your Application Demands Low Noise Power ...

...You've probably had to put up with bulky, inefficient linear power supplies to get the low ripple that wide-dynamic-range signal conditioning applications demand. In test and measurement, medical imaging, quality audio, RF, or other demanding applications, even the best switchmode power supplies haven't been able to deliver the combination of line harmonic rejection and low switching noise that your system demands. If you've ever wished for the noise performance of a linear in the space of a switcher, then...

Vicor Has The Solution...

Our high-frequency conversion architecture redefined the state-of-the-art in terms of power density and efficiency. Now we're introducing the **Ripple Attenuator Module™**, a modular companion to our family of VI-200 converters which offers the noise performance of a linear while achieving power densities up to 23 Watts/cubic inch!

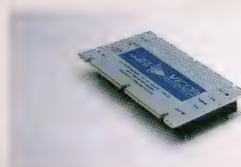
Add a **Ripple Attenuator Module™** to any Vicor VI-200™ converter, MegaModule™, MasterModule™ or FlatPAC™ with output voltages from 5 to 50 Volts and limit total output noise to less than **2mV, peak-to-peak** at loads up to 10 Amps. Combining active and passive filtering, RAMs attenuate both low frequency line harmonics and high frequency switching components in the range of DC to 20 MHz...by approximately 40 dB. No adjustments are required, and remote sense and output voltage trim features are retained.

RAMs Are Available In Three Product Grades:

■ Commercial	0°C to +85°C	VI-RAM-C1
■ Industrial	-40°C to +85°C	VI-RAM-I1
■ Military	-55°C to +100°C	VI-RAM-M1

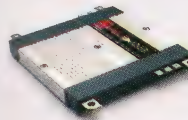
VI-RAMs Are Designed For Use With The Following Products:

VI-200™ Series DC-DC Converters and Power Boosters™



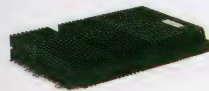
- 12 to 300 VDC nom. inputs
- Single output, 2-95 Volts
- 50, 75, 100, 150, 200 Watts
- Up to 36 Watts/cubic inch
- UL, CSA, TUV

Mega/Master Module™ Series High Power DC-DC Converters



- 12 to 300 VDC nom. inputs
- Single, dual and triple output
- Up to 600 Watts
- Up to 27 Watts/cubic inch
- UL, CSA, TUV

FlatPAC™ Series High Power AC-DC Switchers



- 115/230 VAC strappable
- Single, dual and triple output
- Up to 600 Watts
- Up to 7 Watts/cubic inch
- UL, CSA, TUV

If you'd like to try a VI-RAM, or want to know more about our complete family of component-level power products, call Vicor today at (800) 735-6200. For immediate delivery of Vicor products ask for Vicor Express at Ext. 265.

Component Solutions For Your Power System



Do you have to design in

*Coding and Remote
Debugging*

RTAda; model: Robot controller

```

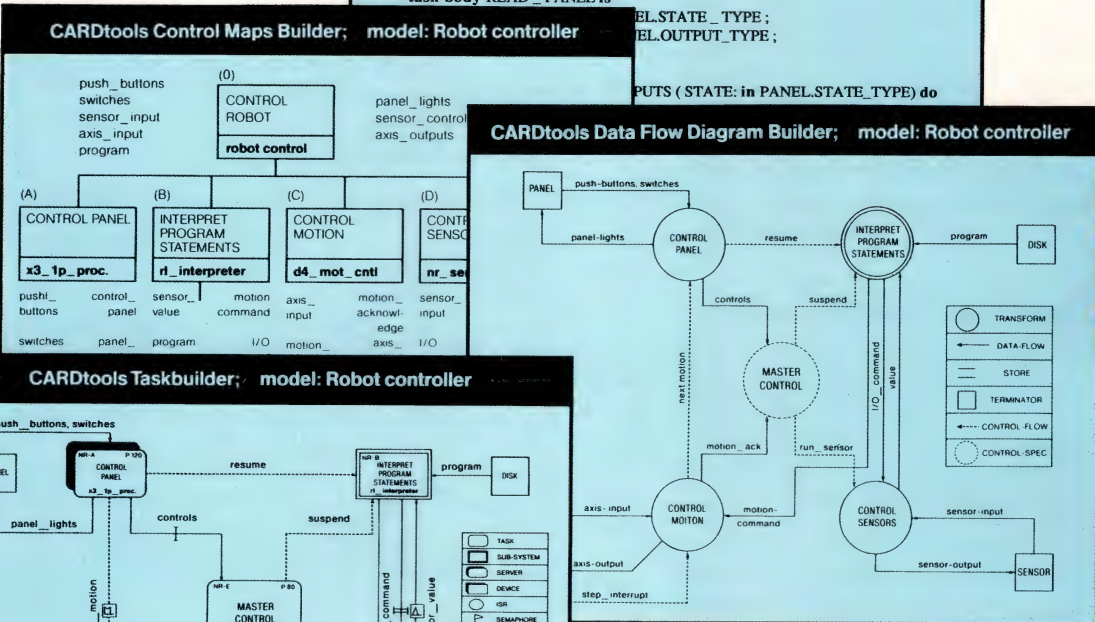
package body PANEL is

  task READ_PANEL is
    entry PANEL__INPUTS (STATE : in PANEL.STATE__TYPE);
  end READ_PANEL;

  task body READ_PANEL is
    ...
  end READ_PANEL;

end PANEL;
    
```

Detailed Design



HYPERLINK

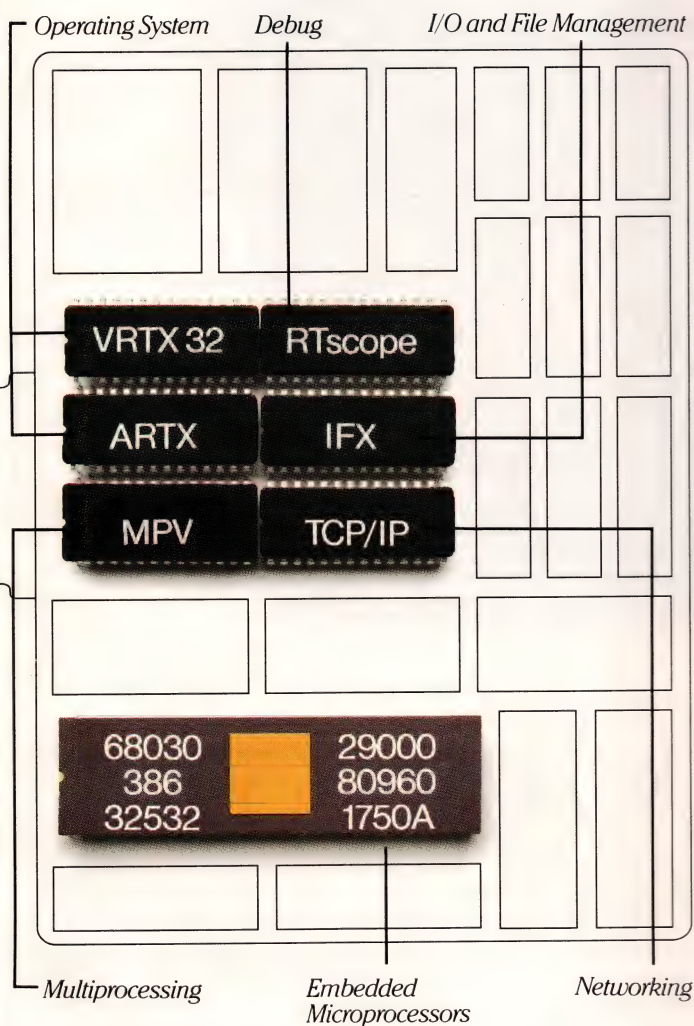
*High Speed
Downloading*

Requirements

*High Level Design
and Performance
Analysis*

HOST

what it takes real-time?



TARGET

Successful real-time design for embedded systems takes more than extraordinary helpings of craft and creativity. It also takes the right tools. Which may explain why our CARD (Computer-aided Real-time Design) technology is behind the development of well over fifty million lines of real-time code.

We're not talking about ordinary tools spruced up with a few real-time extensions. CARD technology was created exclusively for the real-time world specifically for integrating run-time and software development environments.

We are talking about tools such as reusable software components like VRTX®, the real-time operating systems standard. Real-time implementations of C and Ada. Automated analysis tools for verifying system performance. Our CARDtools™ product gives you everything you need including specifically tailored design aids to manage software organization and data flow.

And automated documentation so complete, so accurate, it satisfies even the DoD's rigid 2167A specs. Not to mention the demands of our hundreds of exacting commercial customers.

So if you'd like to have what it takes to make your next real-time project run more efficiently call us, toll free, at (800) 228-1249. Or (214) 661-9526 in Texas.

Because you can only be a success in real-time design if you've got the right stuff.

♦ **READY
SYSTEMS**

Measurement
and display
system

IEEE-488/
RS232C/TTL
remote control

Multi-speed
automatic
calibration
verification

Shock isolated
transport

Universal
power supply
(120/240V,
47-440 Hz)

Direct
record/reproduce
to 2 MHz

End of tape
warning

Internal
calibration
system

All mode FM

Independent
FM bandwidth
selection

© 1989 Honeywell Inc.

BREEZE THROUGH ANY TEST.

Want to be confident that you'll accurately capture all the data you need in most any kind of test?

Just hook up with the Honeywell Model 101e—an enhanced version of the rugged Model 101 that has proven its reliability in a wide range of applications over many years.

Augmenting the many qualities of its predecessor, the Model 101e features: preamble recording with a "known" signal • microprocessor-controlled auto test for calibration verification at the speed you select • total system control via a direct-access panel • gentle tape handling • 5-year/5,000-hour unpro-

rated warranty on the ferrite heads • field services and a worldwide parts network unsurpassed for more than 30 years.

For details, contact Darrell Petersen, Honeywell Inc., Test Instruments Division, Box 5227, Denver, CO 80217-5227. (303) 773-4835.

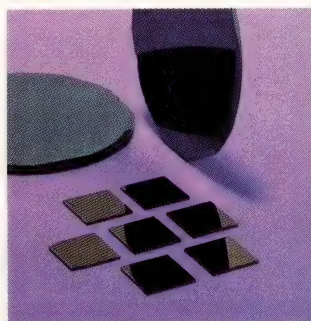
Honeywell

HELPING YOU CONTROL YOUR WORLD

Crystals for Demanding Needs

Garnet LPE film for optical isolators

Laser diodes are a critical light source for optical communications and memories, but noise generated by outside reflected light can cause a significant drop in performance. TOKIN's **Garnet LPE (Liquid Phase Epitaxy) Film**, with its superior magneto-optical characteristics,



makes an outstanding Faraday rotation isolator to prevent light from reflecting back to the diode. And it's one of many Tokin crystal products designed to meet your needs.

Acoustooptic modulation medium

TOKIN's **Tellurium Dioxide Single Crystal**



(TeO_2) is the perfect material for acoustic modulators and deflectors, a key component of laser printers, color scanners and spectrum analyzers. With an optically transparent wavelength of $0.35 \sim 5 \mu\text{m}$, it



is ideally suited to modulation and deflection of visible light lasers (such as He-Cd laser [441.6 nm]).

For acoustooptic light deflectors in laser printers, facsimiles and other record-

ing equipment, TOKIN offers **Lead Molybdate Single Crystal (PbMoO_4)**. This



material permits higher frequencies, a wider bandwidth, high diffraction efficiency and high temperature stability—all of which add up to high-speed deflection. Yet another Tokin crystal product with an avid following.

Call us now.

• Garnet LPE Films for optical isolator (1.3 and 1.55 μm)

Composition	($\text{GdBi}_{1-x}\text{Fe}_x$)($\text{Ga}_{1-x}\text{Al}_x$) O_2	($\text{TbBi}_{1-x}\text{Fe}_x$) O_2
Faraday rotation angle (deg.)	45 ± 0.5	45 ± 0.5
Insertion loss (dB/45°)*	≤ 0.3	< 0.4
Change of Faraday rotation by temperature (deg./K)**	0.08	0.04
Extinction ratio (dB)*	> 35	> 35
Field for saturation magnetization (Oe)	~ 200	~ 700

* With anti-reflection coat ** Wavelength at 1.3 μm

• Garnet LPE Films for magnetic sensor (0.8 μm)

Composition	($\text{RBi}_{1-x}\text{Fe}_x$) O_2 R: Rare-earth elements
Verdet constant (deg./Oe)	2×10^{-2}
Insertion loss (dB/45°)*	$< 2 \sim 3$
Field for saturation magnetization (Oe)	~ 1500

* With anti-reflection coat, magnetic garnet film = 30 μm .

TOKIN

Tokin Corporation

Hazama Bldg., 5-8, Kita-Aoyama 2-chome, Minato-ku, Tokyo 107, Japan
Phone: 03-402-6166 Fax: 03-497-9756 Telex: 02422695 TOKIN J

Tokin America Inc.

155 Nicholson Lane, San Jose, California 95134, U.S.A.
Phone: 408-432-8020 Fax: 408-434-0375

Chicago Branch

9935 Capitol Drive, Wheeling, Illinois 60090, U.S.A.
Phone: 312-215-8802 Fax: 312-215-8804

Tokin Electronics (H.K.) Ltd.

Room 806 Austin Tower, 22-26A Austin Avenue, Tsimshatsui, Kowloon, Hong Kong
Phone: (3) 679157 ~ 9 Fax: (3) 7395950

Taiwan Liaison Office

7/F-2, No. 200, Sec. 3, Hsin-Yi Road, Taipei
Phone: (02) 7059310-1 Fax: (02) 7015650

München Liaison Office

Elisabethstraße 21, 8000 München 40, Bundesrepublik Deutschland
Phone: (089) 271 75 22 Fax: (089) 271 75 67
Telex: 5 24 537 tokin d

You can reach our agents by phone: Denmark (03) 63 3830; France (1) 45-34-7535; Italy (0331) 67-8058; Spain 729-1155; Switzerland (01) 830-3161

ZAX Presents The Best Way To Develop, Program, Edit, Erase, Compile, Assemble, Debug And Compute



Along with everything else shown here, we offer emulators for the following processors: 8086/88, 186/188, 80286, 80386, 8085, 8048, V20/30, V40/50, 6301, 64180, 6809, 68000, 68020, 68030. And yes, more are on the way.

If you're dissatisfied with the formidable task of trying to assemble a suitable microprocessor development system from different vendors, take heart. Now with a simple phone call, you can receive *complete support* for all your development equipment needs from one supplier—ZAX Corporation!

WHY DOES SINGLE-VENDOR SUPPORT MAKE SENSE?

When you turn your development needs over to ZAX, you're assured that all hardware and software tools were conceived, designed and tested to work together reliably and efficiently. Both with your existing system or as a completely independent development system.

That coordination results in a complete turnkey development system instead of a collection of unmatched components. (Surprising as it seems, this modular approach to design tools still costs less than dedicated systems, yet offers more flexibility!) Also, by providing a package instead of a puzzle, you end up conserv-

ing another important resource: Time. One phone call. One purchase order. One solid commitment. No headaches.

WHAT TYPE OF HARDWARE AND SOFTWARE TOOLS ARE WE TALKING ABOUT?

ZAX offers you a choice of two different powerful emulation systems with the ICD- and ERX-series emulators. Both can be interfaced to a variety of hosts (from PC to mainframe) and both offer support for a wide variety of processors. There's also our universal interface chassis, the 300i, that's capable of linking our emulators to virtually all host computers and operating systems. And speaking of computers, ZAX can provide you with a model of its own—the BOX-ER.

ZAX can also furnish an array of useful support hardware, such as a line of PLD/EPROM programmers and erasers. Our ZP-series high-speed programmers interface to your PC for a powerful combination. And the ZE-series line of EPROM erasers include everything from an indus-

trial-class, 200-chip model to the world's fastest eraser, the 5-second Quick-E II.

Chances are a broad choice of development software is paramount to your ability to work in a familiar environment. If so, ZAX is still your best source. We offer "C," Pascal, Ada, PL/M and Fortran compilers, assemblers/loaders, symbolic debuggers, source-level debuggers, and helpful menu-driven communications programs to get you up and running, fast.

Call ZAX today and get single-vendor support working for YOU! Our toll-free number is 1-800-421-0982 (800-233-9817 in CA). ZAX Corporation. 2572 White Road, Irvine, California, 92714.

In Europe, call United Kingdom: 0628 476 741, West Germany: 02162-3798-0, France: (03) 956-8142, Italy: (02) 688-2141.

ZAX
Zax Corporation

Rely on semiconductor basics to identify transistor problems

Although transistors—both bipolars and MOSFETs—are immune to many problems, you can still have transistor troubles. Robust design methods and proper assumptions regarding their performance characteristics will steer you past the shoals of transistor disasters. After taking on 2-terminal devices in part 6, Bob covers these 3-terminal devices. Future parts will cover analog ICs.

Robert A Pease, *National Semiconductor Corp*

Transistors are wonderful—they're so powerful and versatile. With a handful of transistors, you can build almost any kind of high-performance circuit: a fast op amp, a video buffer, or a unique logic circuit.

On the other hand, transistors are uniquely adept at causing trouble. For example, a simple amplifier probably won't survive if you short the input to the power supplies or the output to ground. Fortunately, most op amps include forgiving features, so that they can survive these conditions. When the μ A741 and the LM101 op amps were designed, they included extra transistors to ensure that their inputs and outputs would survive such abuse. But an individual transistor is vulnerable to damage by excessive forward or reverse current at its input, and almost every transistor

is capable of melting. So it's up to us, the engineers, to design transistor circuits so that the transistors do not blow up, and we must troubleshoot these circuits when and if they do.

A simple and sometimes not so obvious problem is installing a transistor incorrectly. Because transistors have three terminals, the possibility of a wrong connection is considerably greater than with a mere diode. Small-signal transistors are often installed so close to a printed-circuit board that you can't see if the leads are crossed or shorted to a transistor's can or to a pc trace. In fact, I recall some boards in which the leads were often crossed and about every tenth transistor was the wrong gender—pnp where an npn should have been, or vice versa. I've thought about it a lot, and I can't think of any circuits that work equally well when you install a transistor of the opposite sex. So, mind your Ps and Qs, your Ps and Ns, and your 2N3904s and 2N3906s.

In addition to installing a transistor correctly, you must design with it correctly. First of all, transistors require input protection. Most transistors can withstand dozens of milliamperes of forward base current but will die if you apply only a few volts. One of my pet peeves has to do with adding protective components. MIL-HDBK-217 has always said that a circuit's reliability decreases when components are added. Yet when you add resistors or transistors to protect an

With a handful of transistors, you can build almost any kind of high-performance circuit, including fast op amps, video buffers, and unique logic circuits.

amplifier's input or output, the circuit's reliability actually improves. It just goes to show that you can't believe everything you read in a military specification. For a specific criticism of the notion of computing reliability per MIL-HDBK-217, see **Ref 1**.

Similarly, if you pump current out of the base of a transistor, the base-emitter junction will break down. This reverse current—even if it's as low as nanoamperes or very brief in duration—tends to degrade the beta of the transistor, at least on a temporary basis. So in cases where accuracy is important, find a way to avoid reverse biasing the inputs.

Transistors are also susceptible to ESD. If you walk across a rug on a dry day, charge yourself up to a few thousand volts, and then touch your finger to an npn's base, it will probably survive because a forward-biased junction can survive a pulse of a few amperes for a small part of a microsecond. But, if you pull up the emitter of a grounded-base stage, you risk reverse-biasing the base-emitter junction. This reverse bias can cause significant damage to the base-emitter junction and might even destroy a small transistor.

When designing an IC, smart designers add clamp diodes, so that any pin can survive a minimum of $\pm 2000\text{V}$ of ESD. Many IC pins can typically survive two or three times this amount. These ESD-survival design goals are based on the human-body model, in which the impedance equals 100 pF in series with 1500Ω . In discrete transistors, whose junctions are considerably larger than the small geometries found in ICs, ESD damage may not be as severe. But in some cases, ESD damage can still happen. Delicate RF transistors such as 2N918s, 2N4275s, and 2N2369s sometimes blow up "when you just look at 'em" because their junctions are so small.

Other transistor-related problems arise when engineers make design assumptions. Every beginner learns that the V_{be} of a transistor decreases by about 2 mV per degree Celsius and increases by about 60 mV per decade of current. Don't forget about the side effects of these rules, or misapply them at extreme temperatures. Don't make sloppy assumptions about V_{be} s. For instance, it's not fair to ask a pair of transistors to have well-matched V_{be} s if they're located more than 0.1 in. apart and there are heat sources, power sources, cold drafts, or hot breezes in the neighborhood. Matched pairs of transistors should be glued together for best results.

I've seen people get patents on circuits that don't



Photographs by Peggi Willis

A curve-tracer can help you discern the difference between a "good" transistor and a "bad" one. It can also help resolve the shape of the voltage-current curve of any nonlinear component.

even work based on misconceptions of the relationships between V_{be} and current. It's fair to assume that two matched transistors with the same V_{be} at the same small current will have about the same temperature coefficient of V_{be} . But you wouldn't want to make any rash assumptions if the two transistors came from different manufacturers or from the same manufacturer at different times. Similarly, transistors from different manufacturers will have different characteristics when going into and coming out of saturation, especially when you're driving the transistors at high speeds. In my experience, a components engineer is a very valuable person to have around and can save you a lot of grief by preventing unqualified components from confusing the performance of your circuits.

Another assumption engineers make has to do with a transistor's failure mode. In many cases, people say that a transistor, like a diode, fails as a short circuit or in a low-impedance mode. But unlike a diode, the transistor is normally connected to its leads with relatively small lead-bond wires; so if there's a lot of energy in the power supply, the short will cause large currents to flow and vaporize the lead bonds. As the lead bonds deteriorate, the transistor will ultimately fail as an open circuit.

It's nice to design with high-beta transistors, and, "if some is good, more's better." But, as with most things in life, too much can be disastrous. The h-parameter, h_{rb} , equals $\Delta V_{be}/\Delta V_{cb}$ with the base grounded,

and many engineers have learned that as beta rises, so does h_{rb} . As h_{rb} rises, the transistor's output impedance decreases; its Early voltage falls; its voltage gain decreases; and its common-emitter breakdown voltage, BV_{ceo} , may also decrease. (The Early voltage of a transistor is the amount of V_{ce} that causes the collector current to increase to approximately two times its low-voltage value, assuming a constant base drive. V_{Early} is approximately equal to $(1/h_{rb}) \times 26$ mV.) So, in many circuits there is a point where higher beta simply makes the gain lower, not higher.

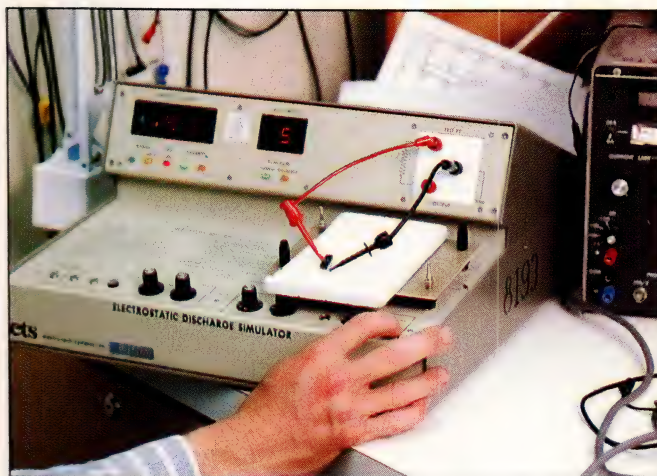
Another way to increase beta is to use the Darlington connection; but the voltage gain and noise may degrade, the response may get flaky, and the base current may decrease only slightly. When I was a kid engineer, I studied the ways that Tektronix made good use of the tubes and transistors in their mainframes and plug-ins. Those engineers didn't use many Darlington transistors. To this day, I keep learning more and more reasons not to use Darlington transistors or cascaded followers. For many years, it's been more important for many circuits to have matched betas than for them to have sky-high betas. You can match betas yourself or buy four or five transistors on one monolithic substrate, such as a monolithic transistor array.

One of the nice things about bipolar transistors is that their transconductance, g_m , is quite predictable. At room temperature, $g_m = 38.6 \times I_C$. Since the voltage gain is defined as $A_V = g_m \times Z_L$, computing it is often a trivial task. You may have to adjust this simple equation in certain cases. For instance, if you include an emitter-degeneration resistor, R_e , the effective transconductance falls to $1/(R_e + g_m^{-1})$. A_V is also influenced by temperature changes, bias shifts in the emitter current, hidden impedances in parallel with the load, and the finite output impedance of the transistor.

For a given operating current, field-effect transistors normally have much poorer g_m than bipolar transistors do. You'll have to measure your devices to see how much lower. Additionally, the V_{gs} of FETs can cover a very wide range, thus making them hard to bias.

Also be aware that although the transconductance of a well-biased transistor is quite predictable, beta usually has a wide range and is not nearly as predictable. So you have to watch out for adverse performance if the beta is too low or too high and causes shifts in your operating points and biases.

JFETs became popular 20 years ago because you could use them to make analog switches with resis-



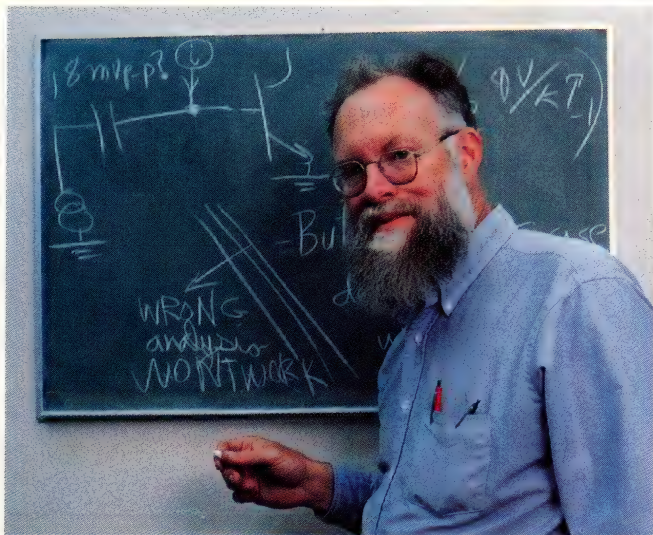
When you hit a component or circuit with a pulse of ESD, you can never be sure what kind of trouble you'll get—unless you've already tested it with an ESD simulator.

tances of 30Ω and lower. JFETs also made good op amps with lower base currents than bipolar devices, at least at moderate or cool temperatures. The BiFET process made it feasible to make JFETs along with bipolars on a monolithic circuit. It's true that the best BiFET inputs are still slightly inferior to the best bipolar ones in terms of voltage-offset temperature coefficient, long-term stability, and voltage noise. But these BiFET characteristics keep improving because of improved processing and innovative circuit design. As a result, BiFETs are very close to bipolar transistors in terms of voltage accuracy and offer the advantage of low input current.

I recall working on a hybrid circuit that had some JFETs whose gate connections were supposed to be through the back of the dice. I found that some of the dice didn't have proper metallurgical processing, which caused some strange behavior. Initially, the gate acted as if it were connected and would act that way for a long period of time. Then, the gate would act like an open circuit with as much as 1V of error between the actual gate and the bottom of the die. The gate would remain disconnected until a voltage transient restored the connection for another week! The intermittency was awful because nothing would speed up the 1-week cycle-to-failure time. So, we had to go back and add definite lead bonds to the gate's bond pad on the top of the chip, which we had been told was unnecessary. Ouch!

When designing hybrids, you need to make sure to

Transistors are powerful and versatile, but they're also uniquely adept at causing trouble.



Using equations to analyze circuits can sometimes help you define a problem. But if the equations are inapplicable, they do a lot more harm than good. This circuit is a version of a patented circuit that was cleverly designed to the highest levels of confidence using equations. The fact that it doesn't work is a mere footnote—except to the engineer who has to troubleshoot it.

connect the substrate of a chip to the correct dc level. The bottom of a FET chip is usually tied to the gate, but the connection may be through a large and unspecified impedance. You have to be a pretty good chemist or metallurgist to be sure that you don't have to add a bond to the gate's metal. A bipolar-transistor die's substrate is the collector. Most linear and digital IC substrates are tied to the negative supply. Exceptions include the LM117 and similar adjustable positive regulators—their substrate is tied to V_{out} . The LM196 voltage regulator's substrate is tied to the positive supply voltage, V_s , as are the substrates of the MM74HC00 family of chips and most of the dielectrically isolated op amps from Harris. So, be aware of your IC's substrate connection. If an LM101AH op amp's metal can bumps against ground or V_s , you have a problem. Similarly, you shouldn't let an HA2525's case bump against ground or $-V_s$.

MOSFETs are widely used in digital ICs but are also very popular and useful in analog circuits, such as analog switches. Op amps with MOSFET inputs do well in the general-purpose op-amp market. MOSFETs have a bad reputation for excessive noise, but new devices, such as the LMC662, demonstrate that clean processing can cure the problem, thus making MOSFETs competitive with BiFETs. Just be careful not to let ESD near the inputs. MOSFETs do have

protection diodes and may be able to withstand 800V, but they can't survive 2000V. If you work with unprotected devices, such as the 3N160, you must keep the pins securely shorted until the device is soldered into its pc board in which the protection diodes are already installed. I do all of that and wash the transistor package with both an organic solvent and soap and water. And, I keep the sensitive gate circuits entirely off the pc board by pulling the gate pin up in the air and using point-to-point wiring. Air, which is a superior dielectric, is also a good insulator (Ref 2). So far, I haven't had any blown inputs or bad leakages—at least nothing as bad as 10 fA.

On the other hand, when using CMOS digital ICs, I *always* plug them into live sockets; I *never* use conductive foam; and I *never* wear a ground strap on my wrist. And I've *never* had any failures—with one exception. One time I shuffled across a carpeted floor and pointed an accusatory finger at a CMOS IC. There was a small crack of ESD—probably 5000V—followed by a big SNAP as the IC blew out and crowbarred the entire power supply. Since ESD testing is done with the power OFF, if you did some tests with the power ON, you might get some messy failure modes like the one I just mentioned. Always be wary of any devices that manufacturers claim are safe from ESD.

Power transistors may hog current

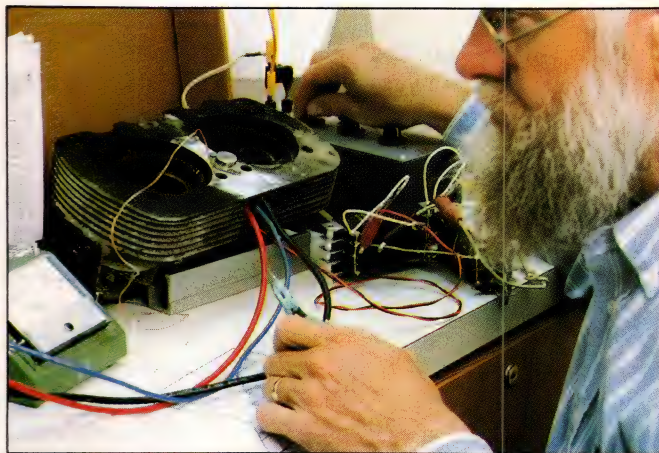
As you build a bipolar transistor bigger and bigger, you may be tempted to go to extremes and make a huge power transistor. But there are practical limitations. Soon, the circuit capacitances cause oppressive drive requirements, and removing the heat is difficult. Still, no matter how big you build power transistors, people will find a use for them. Their most severe problem is secondary breakdown, which is what happens when you drive a transistor outside its safe operating area.

When you operate a power transistor at very high currents and low voltages, the emitter resistance of the device—which includes the resistance of the emitter metal and the inherent emitter resistivity—can cause enough $I \times R$ drop to force the entire emitter and its periphery to share the current. Now, let's halve the current and double the voltage. The amount of dissipation is the same, but the $I \times R$ drop is cut in half. Now continue to halve the current and double the voltage. Soon you'll reach a point where the ballasting (Fig 1) won't be sufficient, and a hot spot will develop at a high-voltage point. The inherent decrease of V_{be}

causes an increase of current in one small area. Unless this current is turned OFF promptly, it will continue to increase unchecked. This "current hogging" may cause the area to melt or crater. The designers of linear ICs use ballasting, cellular-layout, and thermal-limiting techniques, all of which can prevent harm in these cases (Ref 3). Discrete transistors may someday include these features.

Fortunately, many manufacturers' data sheets include permitted safe-area curves at various voltages and for various effective pulse widths. So, it's possible to design reliable power circuits with ordinary power transistors. The probability of an unreliable design or trouble increases as the power level increases, as the adequacy of the heat sink decreases, and as the safety margins shrink. For example, if the bolts on a heat sink aren't tightened enough, the thermal path degrades and the part can run excessively hot.

High temperature *per se* doesn't cause a power transistor to fail. But, if the drive circuitry was designed to turn a transistor ON and only a base-emitter resistor is available to turn it OFF, then at a very high temperature, the transistor will turn itself ON and there will be no adequate way to turn it OFF. However, I once applied a soldering iron to a 3-terminal voltage regulator and then went to answer the phone. When I came back the next day, I discovered that the TO-3 package was still quite hot—300°C, which is normally recommended for only 10 seconds. When I cooled it off, the regulator ran fine and met spec. So, the old dictum that high temperature will necessarily degrade



When using high-power amplifiers, there are certain problems you just never have if you use an extremely large heat sink. This heat sink's thermal resistance is lower than 0.5°C/W.

reliability is not always true. Still, it's a good practice not to get your power transistors that hot and to have a base drive that can pull the base OFF if they do.

You can also run into problems if you tighten the screws on the heat sink too tight or if the heat sink under the device is warped or has bumps or burrs or foreign matter on it. If you tighten the bolt too much, you'll overstress and warp the tab and die attach. Overstress may cause the die to pop right off the tab. The insulating washer under the power transistor can crack due to overstress or may fail after days or weeks or months. Even if you don't have an insulating washer, overtightening the bolts of plastic-packaged power

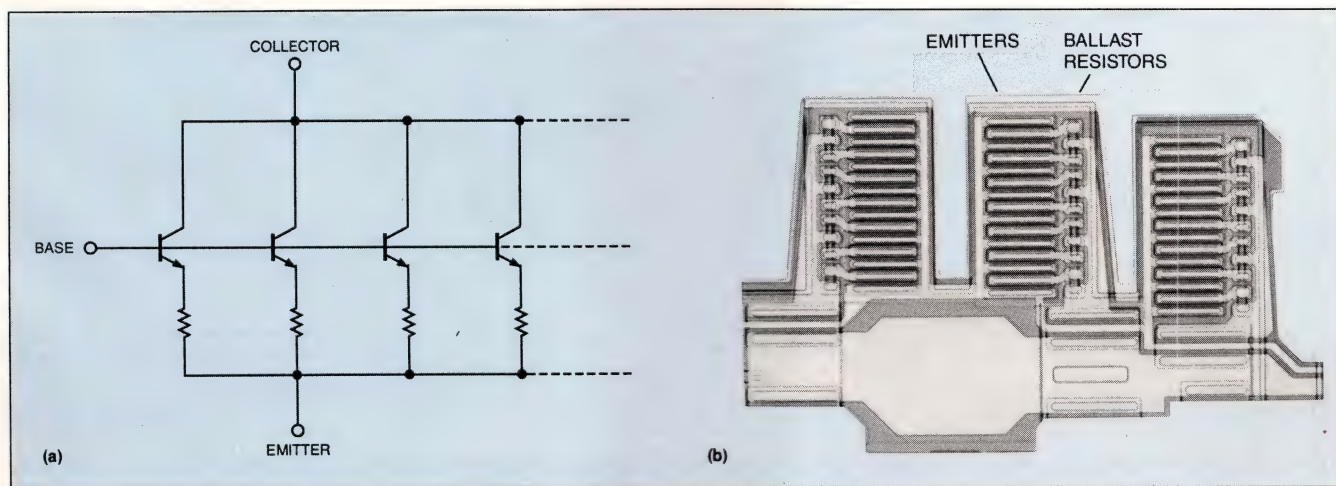


Fig 1—Ballast resistors, also known as sharing resistors, are often connected to the emitters of a number of paralleled transistors (a) to help the transistors share current and power. In an integrated circuit (b), the ballast resistors are often integrated with adjacent emitters. (Photo of National Semiconductor Corp's LM138)

Mind your Ps and Qs and your Ps and Ns; don't mistakenly insert a pnp transistor in place of an npn, or vice versa.

transistors is one of the standard ways to mistreat and kill these devices. Why does the number 10 inch-pounds max, 5 typ, stick in my head? Because that's the spec the Thermalloy man gave me for the mounting bolts of TO-220 packages.

Apply the 5-second rule

Your finger is a pretty good heat detector—just be careful not to burn it with high voltages or very hot devices. A good rule of thumb is the 5-second rule: If you can hold your finger on a hot device for five seconds, the heat sink is about right, and the case temperature is about 85°C. If a component is too hot to touch, dot your finger with saliva and apply it to the hot object for just a fraction of a second. If the moisture dries up quickly, the case is probably around 100°C; if it sizzles instantaneously, the case may be as hot as 140°C. Alternatively, you can buy an infrared imaging detector for thousands of dollars, and you won't burn your fingers.

Fabrication structures make a difference

Another thing you should know when using bipolar power devices is that there are two major fabrication structures: the epitaxial base and the single diffused (Fig 2) (Ref 4). Transistors fabricated with the single-diffused structure are more rugged and have a wide safe-operating area. Epitaxial-base devices feature faster switching speeds but aren't as rugged as the single-diffused types. A good way to compare the two

types is to look at the data sheets for the Motorola 2N3771 and MJ3771. The MJ3771 epi-base device has a current-gain bandwidth 10 times greater than the 2N3771 single-diffused device. The MJ3771 also has a switching speed faster than the 2N3771 when used as a saturated switch, but the 2N3771 has a considerably larger safe area if used for switching inductive loads. You can select which of these characteristics you prefer and order the part according to the specific number.

But there isn't always a clear correlation between the part number and its fabrication structure. For example, the popular 2N3055 is available in both epi-base and single-diffused versions. Since both versions meet and exceed the JEDEC specs, you could end up with either type. If you breadboard with one type and then start building in production with the other, you might suddenly find that the bandwidth of the device has changed by a factor of 10 or that the safe area doesn't match that of the prototypes.

Fortunately, there are ways to order the 2N3055 you want. If you want to buy an ordinary 2N3055—one that meets but does not exceed the device's JEDEC specs—the die will be about 90 mils on a side, the bandwidth will be about 2 MHz, and it will have a nominal safe area because it is an epi-base device. If you want to buy a really gutsy 2N3055, order a 2N3055H from RCA or SGS-Thomson. RCA calls the device's construction hometaxial, which is similar to single diffused. The part's die is about 180 mils on the side, so—obviously—the 2N3055H costs more than the

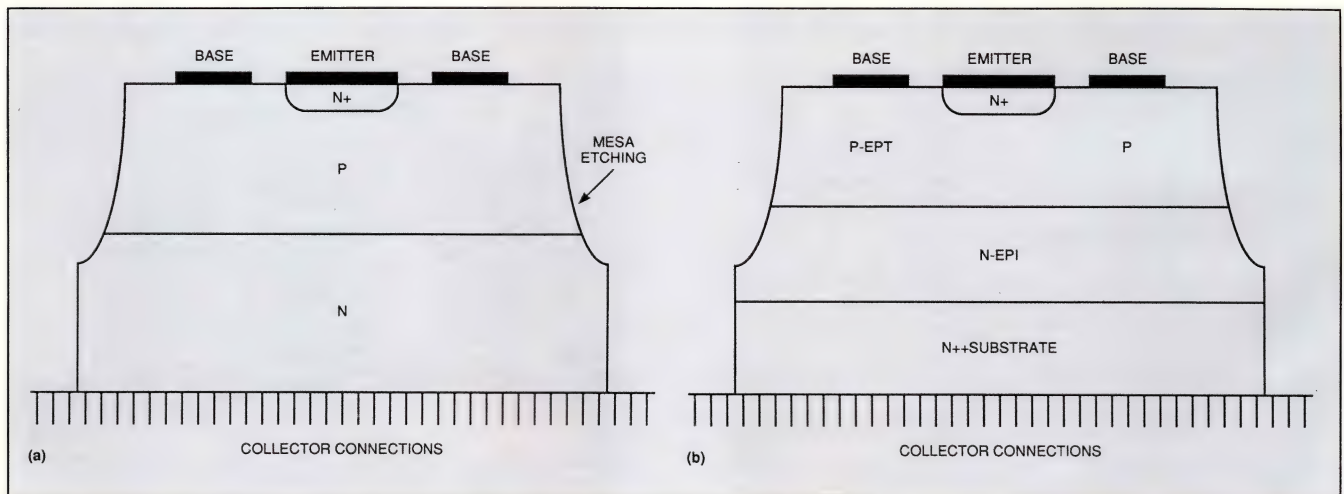
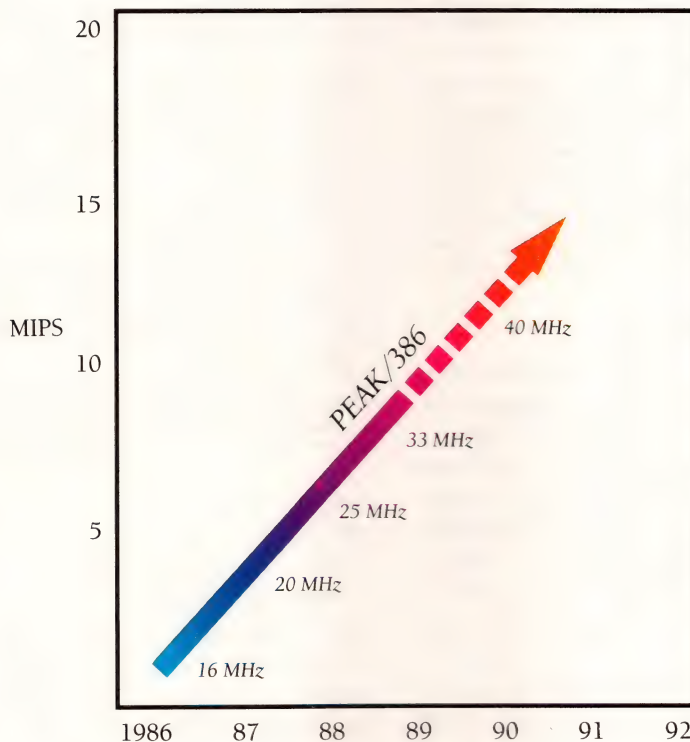


Fig 2—The characteristics of power transistors depend on their fabrication structure. In the single-diffused structure (a), n-type dopants are diffused simultaneously into the front and back of a thin p-type wafer. This structure produces rugged transistors with wide safe operating areas. The more modern epitaxial-base transistor (b) takes advantage of the properties of several different epitaxial layers to achieve higher beta, faster speed, lower saturation, smaller die size, and thus, lower cost. Both structures involve mesa etching, which accounts for the slopes at the die edges.

How to make your 386 system scream.



Introducing the PEAK™ Architecture.

The architecture of the 1990s. And the first technology to let you exploit the full potential of ISA microcomputers.

The PEAK/386 CHIPSet supports 20, 25, 33 and tomorrow's anticipated 40 MHz clock speeds. With the added performance of the industry's only integrated 128K byte cache.

What we're delivering here is raw, unadulterated computing power. With the highest level of integration ever achieved in a 386 chip set.

CPU, cache and DRAM control are integrated onto one VLSI chip. Bus and peripheral control functions are integrated on two other VLSI devices.

These three chips integrate virtually all of the

motherboard system logic. Making it the most cost-effective solution on the market.

The PEAK/386 CHIPSet also tightly couples with our new 82C480 Graphics Controller which is 100% functionally compatible with the IBM® 8514/A Display Adapter. So your system can take full advantage of the new graphical interfaces like Presentation Manager and Windows™ software.

Find out more about the PEAK/386 CHIPSet. Call 1-800-323-4477, Dept. M-9 today.

We promise you it'll be a real scream.

CHIPS®

The CHIPSet is the system.

Transistors require protection against excessive forward and reverse base current and electrostatic discharge.

2N3055. The 2N3055H's bandwidth is only 0.3 MHz, but its safe area is considerably bigger than that of the ordinary 2N3055. Thus, 2N3055Hs are recommended for switching inductive loads.

Be careful not to confuse these epitaxial or single-diffused devices with planar power devices, such as the 2N5039 (Fig 3). The 2N5039 has a frequency response around 60 MHz but a considerably smaller safe area than those of the epitaxial and single-diffused devices. As with smaller transistors, such as the 2N2222 and 2N3904, planar devices tend to oscillate at high frequencies. The judicious use of ferrite beads in their emitter or base leads is often required for stable linear operation.

Power-circuit design requires expertise

For many power circuits, your transistor choice may not be as clear-cut as in the previous examples. So, be careful. Design in this area is not for the hotshot just out of school—there are many tricky problems that can challenge even the most experienced designers. For example, if you try to add small ballasting resistors to ensure current sharing between several transistors, you may still have to do some transistor matching. This matching isn't easy. You'll need to consider your operating conditions; decide what parameters, such as β and V_{be} , you'll match; and figure out how to match different manufacturers' devices. Such design questions are not trivial.

When the performance or reliability of a power circuit is poor, it's probably not the fault of a bad transistor. Instead, it's quite possibly the fault of a bad or marginal driver circuit or an inadequate heat sink. Perhaps a device with different characteristics was inadvertently substituted in place of the intended device. Or perhaps you chose the wrong transistor for the application.

A possible scenario goes something like this. You build 10 prototypes, and they seem to work okay. You build 100 more, and half of them don't work. You ask me for advice. I ask, "Did they ever work right?" And you reply, "Yes." But wait a minute. There were 10 prototypes that worked, but the circuit design may have been a marginal one. Maybe the prototypes didn't really work all that well. If they're still around, it would be useful to go back and see if they had any margin to spare. If the 10 prototypes had a gain of 22,000, but the current crop of circuits has gains of 18,000 and fails the minimum spec of 20,000, your design is not really a failure. It's not that the circuit isn't

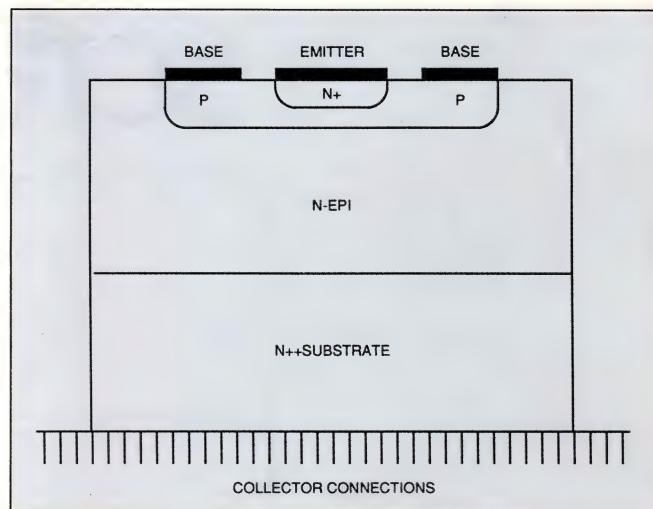


Fig 3—Planar power transistors can achieve very small geometries, small base-widths, and high frequency responses, but they're less rugged than the single-diffused and epitaxial-base types.

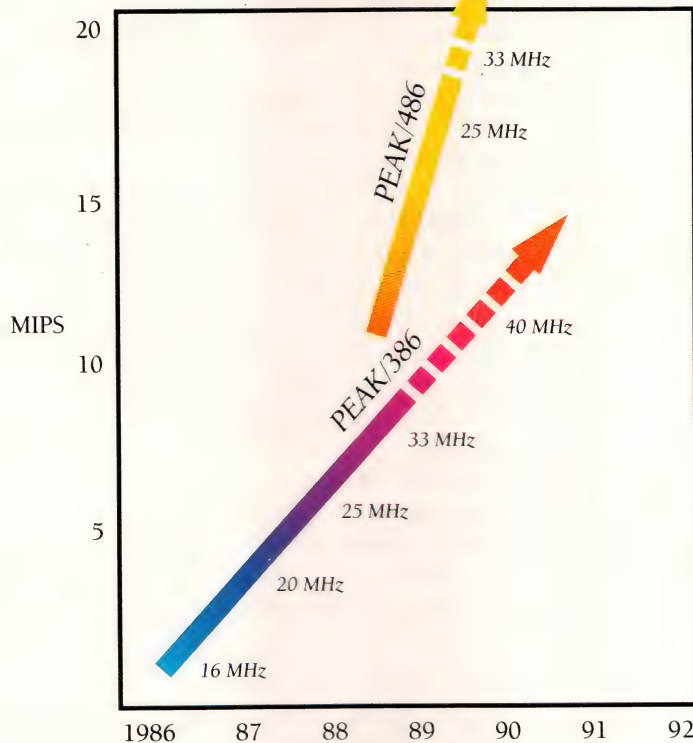
working at all, it's just that your expectations were unrealistic.

After all, every engineer has seen circuits that had no right to work but did work—for a while. And then when they began to fail, it was obviously just a hopeless case. So, which will burn you quickest, a marginal design or marginal components? That's impossible to say. If you build in some safety margin, you may survive some of each. But you can't design with big margins to cover every possibility, or your design will become a monster.

MOSFETs avoid secondary breakdown

When it comes to power transistors, MOSFETs have certain advantages. For many years, MOSFETs have been available that switch faster than bipolar transistors with smaller drive requirements. And MOSFETs are inherently stable against secondary breakdown and current hogging because the temperature coefficient of I_{ds} vs V_{gs} is inherently stable at high current densities. If one area of the power device gets too hot, it tends to carry less current and thus has an inherent mechanism to avoid running away. This self-ballasting characteristic is a major reason for the popularity of MOSFETs over bipolar transistors. However, recent criticism points out that when you run a MOSFET at high enough voltages and low current, the current density gets very small, the temperature coefficient of I_{ds} vs V_{gs} reverses, and the device's inherent freedom from current hogging may be lost (Ref 5). So at high volt-

Now make your 486 system wail.



There is only one way to design a system with more speed and power than a PEAK/386 based system.

Introducing the PEAK/486 CHIPSet. The first and only chip set that takes full advantage of the new 486 microprocessor. Which means you can design a system that literally wails through DOS and unleashes the full power of UNIX®. Right now. Setting the performance standard for PC workstations.

The PEAK/486 and PEAK/386 CHIPSets are based on the same architecture.

And like all our CHIPSets, they come with the most comprehensive technical support in the industry.

Our Design Services Organization will help you with everything from technical consultation to the design of a turnkey microcomputer system.

And our Integrated Software organization will ensure system compatibility by providing BIOS and system software drivers specifically for your PEAK™ system.

To find out more, call 1-800-323-4477, Dept. M-10 today.

And design a system that will take you through the top of the charts. Period.

CHIPS

The CHIPSet is the system.

Don't be too quick to blame circuit problems on a transistor; the designer may have made some sloppy assumptions or had false performance expectations.

ages and low current densities, watch out for this possibility.

The newer power MOSFETs are considerably more reliable and less expensive than the older devices. Even though you may need a lot of milliamps to turn the gate ON or OFF quickly, you don't need a lot of amps to hold it ON like you do with a bipolar transistor. You can turn the newer devices OFF quicker, too, if you have enough transient gate drive current available.

However, MOSFETs are not without their trouble spots. If you dissipate too many watts into a MOSFET, you can melt it just as you can melt a bipolar device. If you don't overheat a MOSFET, the easiest way to cause a problem is to forget to insert a few dozen or hundred ohms of resistance or a ferrite bead right at the gate lead of the device. Otherwise, these devices have such high bandwidths that they can oscillate at much higher frequencies than bipolar transistors.

For example, the first high-fidelity, all-MOSFET audio amplifier I ever saw blew up. It worked okay in the lab, but some misguided engineer decided that if a bandwidth of 5 Hz to 50 kHz was good, then 0.5 Hz to 500 kHz was better. Consequently, when the speaker cables were extended from 10 feet to 20 feet for a demonstration, the amplifier broke into a megahertz-region scream and promptly went up in smoke because of the lack of damping at the sources. I was told that after a minor redesign the amplifier was perfectly reliable. The redesign involved cutting the bandwidth down to a reasonable level, adding some ballasting in the sources, and tying antisnivet resistors directly to the gate pins. (Note: A snivet is a nasty, high-frequency oscillation originally found in vacuum-tube TV sets.)

As with bipolar transistors, MOSFETs are very reliable if you don't exceed their voltage, current, or temperature ratings. Dissatisfaction with a device's reliability or performance usually stems from the drivers or the related circuitry. Most MOSFETs have a maximum V_{gs} rating of just 20 or 25V. A MOSFET may temporarily survive operation with 30 or 50V on the gate, but it's not safe to run it up there forever. If you apply excessive gate voltage, gradual gain or threshold degradation may occur. So—please—don't. Also, power MOSFETs are not quite as rugged as bipolars when it comes to surviving ESD transients. A common precaution is to add a little decoupling, clamping, or current-limiting circuitry, so that terminals accessible

to the outside world can withstand ESD.

DMOS FETs are so easy to apply that we usually forget about the parasitic bipolar transistor that lurks in parallel with them. If $[dV/dt]$ is too large at the drain, the drain junction is avalanched at too high a current and voltage, or the transistor gets too hot, the bipolar device turns ON and dies an instant death due to current hogging or an excursion from its safe operating area.

But I'm spoiled rotten. I'm accustomed to linear ICs, which have protection transistors built right in, so most of the transistor troubles are left to the IC designer. Discrete designs are appropriate and cost-effective for many applications, but the availability of linear ICs—especially op amps—eases your design task considerably. Next time, we'll discuss the ins and outs and innards of op amps.

EDN

References

1. Leonard, Charles, "Is reliability prediction methodology for the birds?" *Power Conversion and Intelligent Motion*, November 1988, pg 4.
2. Pease, Robert A, "Picoammeter/calibrator system eases low-current measurements," *EDN*, March 1, 1982, pg 143.
3. "A 150W IC Op Amp Simplifies Design of Power Circuits," R J Widlar and M Yamatake, AN-446, National Semiconductor Corp, Santa Clara, CA.
4. Applications Engineering Staff, PowerTech Inc, "Speed-up inductor increases switching speed of high current power transistors," *Power Electronics*, May 1989, pg 78.
5. Passafiume, Samuel J, and William J Nicholas, "Determining a MOSFET's real FBSOA," *Powertechnics Magazine*, June 1989, pg 48.

Author's biography

For information about Bob Pease, see the **box**, "Who is Bob Pease, anyway?" on page 148 of the January 5, 1989, edition of *EDN*.

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

TEXAS INSTRUMENTS

A PERSPECTIVE ON DESIGN ISSUES:

Getting on and off the bus faster

IN THE ERA OF

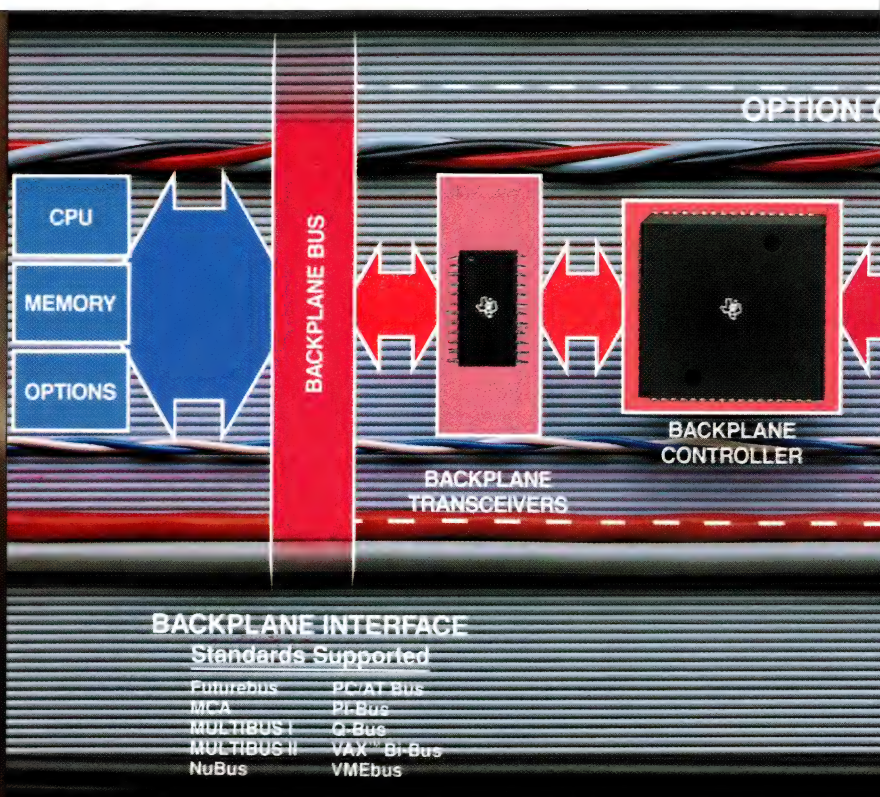
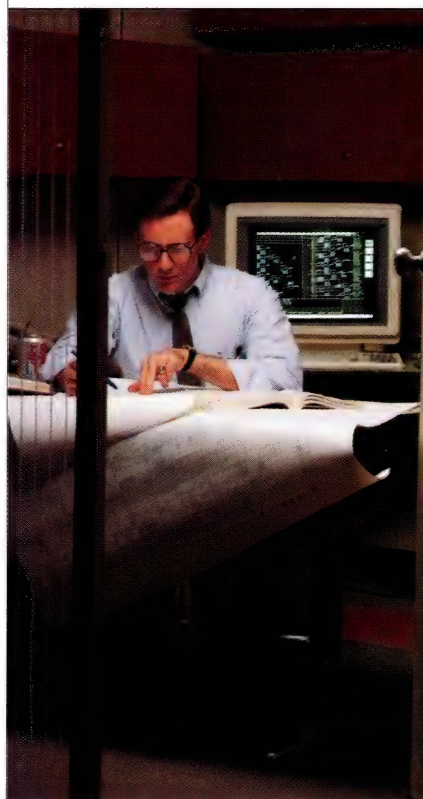
MegaChip

TECHNOLOGIES



New bus interface ICs from TI can keep your total system up to speed.

You not only increase system throughput but cut power and conserve real estate at the same time.



What use is a high-performance CPU if its processing power can't be delivered to the backplane and outward to the peripherals?

Typically, some system throughput is lost at the local bus interface, some at the backplane interface, and some at the peripheral bus interface.

To help you minimize such losses and maximize system throughput, Texas Instruments offers a series of innovative chips for (1) backplane interface and (2) peripheral bus interface, as well as (3) controllers to regulate data flow.

These devices support the major industry standards listed above so that you can achieve system compatibility regardless of the bus you are implementing.

High-speed, low-power implementation of backplane and peripheral interfaces for most popular standards is made possible by TI's comprehensive family of both digital and analog physical-layer

Superior backplane interface performance

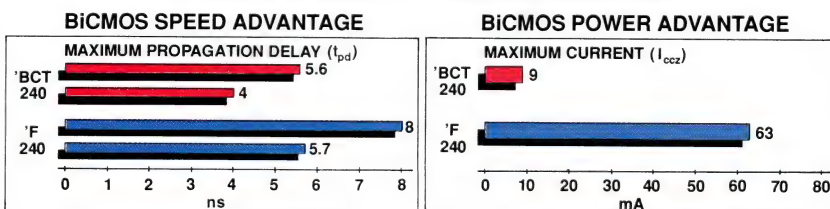
To maximize system throughput, data must be able to get on and off the bus quickly. Therefore, the backplane bus transceivers must be capable of high speed and high drive.

Our high-speed/low-power BiCMOS logic (SN54/74BCTXXX)

is specifically designed for bus interface applications.

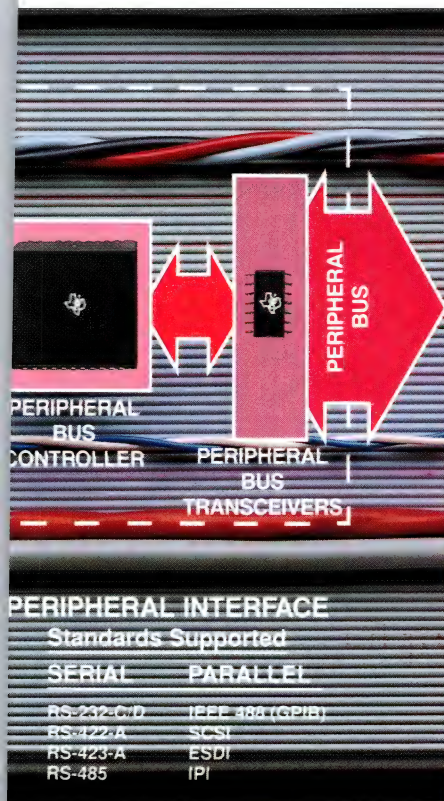
As the name implies, TI BiCMOS merges low-power CMOS with high-speed bipolar, delivering switching speeds comparable to advanced bipolar devices. You also get the 48/64-mA

BiCMOS VERSUS ADVANCED BIPOLAR



The BiCMOS lead over bipolar is proven by this comparison between TI's '74BCT240 and a comparable advanced bipolar standard device. Typical propagation delay of TI's BiCMOS part is faster (left) while power dissipation is less (right).

TI's MegaChip™ Technologies are the means by which we can help you and your company get to market faster with better, more competitive products. Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers.



CMOS devices. Your answer lies with TI's Linear BiCMOS family.

Included are low-power versions of industry-standard quad drivers and receivers (SN75C188/89). Driver/receiver combinations, ranging from single to quad combinations (SN75C1154), substantially cut package count.

This BiCMOS technology will also allow us to provide charge pump circuitry for single 5-V operation.

Where data rates are high and line lengths are long, as the newer peripherals demand, noise can become a major problem. It is overcome by the use of differential drive. Typically, the major application requirement is higher speeds at, ideally, lower power.

For example, disk drives using ESDI, IPI, or SCSI interfaces will benefit from TI's SN75ALS17X devices conforming to RS-422-A and/or RS-485 standards. These chips are fabricated using our unique IMPACT™ processing that delivers up to 50% greater speed compared to competing products with as much as a 30% power reduction.

IMPACT processing is also behind the unmatched speed of our SN75AS030 RS-422 dual driver/receiver. Typical propagation delays are only 6 ns. ■

No matter which of TI's innovative devices you choose to improve speed, cut power, and reduce real estate at the media interface, the complete bus interface requires another element — controllers. For details on how TI is addressing your needs in this area, turn the page.



ICs. To complete the implementation, TI offers a series of innovative standard and ASIC control devices. Use of TI's leadership bus interface devices can help shorten system design cycles.

drive current you need, and total system power savings can be as high as 25% (see charts).

There are more than 60 members in our BiCMOS family, including 8-, 9-, and 10-bit latches, buffers, drivers, and transceivers. The family is also available in military versions.

Our family of octal ECL translators (SN10KHT/100KTXXXX) delivers a low-power, high-speed translator solution with 48 mA of

drive capability on the TTL side.

Our high-speed Futurebus transceiver family (SN55/75ALS-05X) includes quad and octal devices compatible with Futurebus implementations of the IEEE 896.1 standard. With a drive capability of 100 mA, a 5-ns (typ) propagation delay, and a supply current of 65 mA (max), our SN75ALS053 has the best speed/power ratio of any Futurebus transceiver on the market today. ■

High-performance peripheral interfaces

Peripheral bus interface design decisions revolve around trade-offs between line length, data rate, and noise immunity.

Where data rates are low and

line lengths are short, as with the popular RS-232-C/D standard, the major concern is power savings. However, relatively high voltages (30 V) prevent the use of standard

High-performance controllers make system design easier.

While the majority of physical-layer devices—those used to implement backplane and peripheral interfaces—transmit data, your system design also requires a device to regulate the flow of that data through the bus interface. To do the job, TI offers a series of controllers that simplify and shorten your task while cutting chip count and improving overall system throughput.

Simplified NuBus design

TI has taken much of the work out of NuBus™ design by introducing the industry's first standard NuBus interface devices. They are the SN74ACT2440 NuBus Controller and the SN74BCT2420 NuBus Registered Transceiver.

A typical implementation, using two 16-bit transceivers and one 32-bit controller (see below), replaces as many as 45 discrete devices. Compared to a discrete approach, this solution uses 60% less board space and 90% less power.

Because the necessary logic is embedded within the controller, design cycle time is reduced significantly.

A low-power UART

There is now more need than ever for low-power RS-232 interfaces. Our TL16C450 Universal Asynchronous Receiver/Transceiver (UART), made with CMOS process technology, is an excellent choice for desktop applications and is especially suited for use in lap-top/battery-powered units.

A flexible SCSI controller

Available soon, our SCSI controller (designed to conform to ANSI X3.131-1986 specifications) will deliver data rates of 3 Mbytes/s (asynchronous) and 5 Mbytes/s (synchronous).

Unique byte-stacking control logic will allow interface to 16-, 24-, and 32-bit buses. The TI controller will also provide powerful multi-phase SCSI commands, including automatic handling of save-data pointer to minimize interrupts to the host processor. Dual 32-byte FIFOs will provide smooth, efficient buffering between processor and DMA ports.

Customized controllers, too

The NuBus and UART controllers

are available as part of our ASIC standard-cell library.

In addition, TI offers TGC100 Gate Arrays and TSC500 Standard Cells as part of our ASIC family which allows you to build the precise chip functions you need. ■

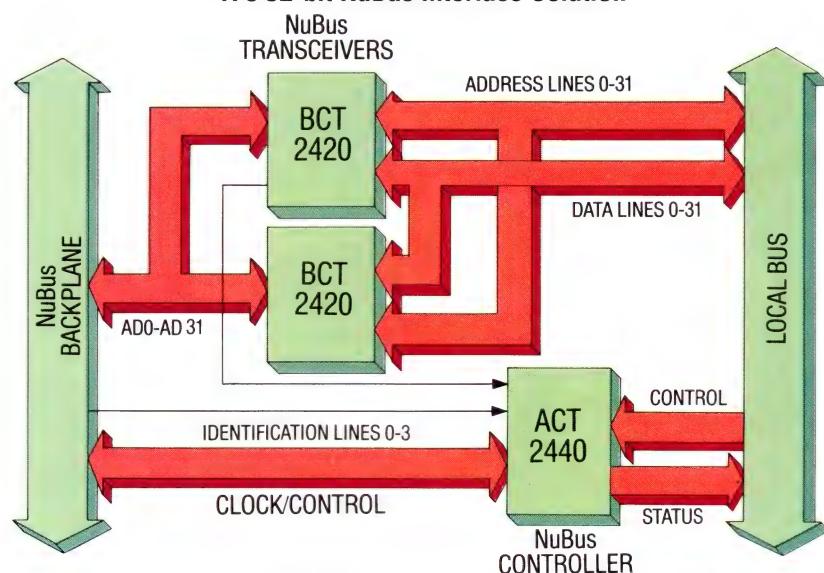
System complexity and the future

As systems become more and more complex, the need will emerge for combining the functionality of controllers and physical-layer devices on a single chip. To that end, TI is applying its acknowledged expertise in physical-layer devices to the design and development of such advanced control-level ICs.

System complexity also brings with it the need for simulation models to make design easier and faster. As a result, we already have simulation models available for more than 1,300 TI devices, including BiCMOS bus interface and ACL logic devices.

Another issue is the increasing difficulty and expense of testing boards in complex systems. Consequently, TI supports the JTAG/IEEE P1149.1 standard with the development of standard products and ASICs having on-chip test cells, as well as with development support software and device models on several leading workstations. ■

TI's 32-bit NuBus Interface Solution



Major space savings are realized by using one TI SN74ACT2440 controller and two SN74BCT2420 transceivers to complete a full 32-bit NuBus master/slave interface. As many as 45 discrete logic devices are replaced, realizing significant reductions in board space, power consumption, and design cycle time.

Please call 1-800-232-3200, ext. 3905, for your copy of our Bus Interface Devices brochure. Or write Texas Instruments Incorporated, Dept. SSY25, P.O. Box 809066, Dallas, Texas 75380-9066.

™ MegaChip, IMPACT, and NuBus are trademarks of Texas Instruments Incorporated. VAX is a trademark of Digital Equipment Corporation.

© 1989 TI

08-8444

TEXAS
INSTRUMENTS

One Of A Kind.

Introducing DrawingMaster™

*High resolution—
Up to 400x200 dpi.*

*No toners, pens, ribbons,
chemicals or hassles.*

*Black and
red colors.*

*High speed—
Up to 3.5 ips.*

*Quiet
operation.*

Mobility.

This one-of-a-kind raster plotter from CalComp breaks all the rules—making it our total output solution for your every design requirement.

In one word, performance. With four modes of operation to choose from, this dynamo will produce A to D size plots in no time at all.

Sharp, clean plots and unattended operation in any environment increases your productivity. Add to that shared resource plotting with a 4 to 1 mux and you've got complete versatility.

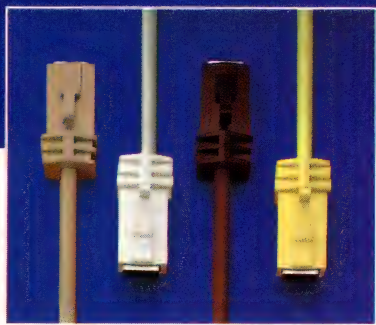
Top it off with quick installation, the reliability of virtually no moving parts, and you'll agree—it's the only one-of-a-kind you'll ever need.

With DrawingMaster also comes CalComp's 30 years of expertise, support and service, complete with an 800 helpline, which, because of the solid performance of DrawingMaster, you'll probably never need.

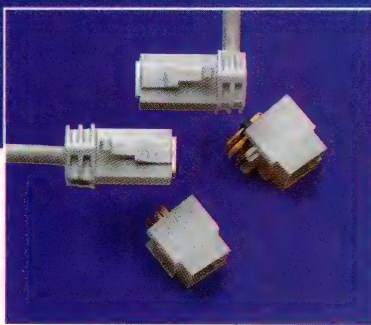
Like more on this no-fuss wonder?
Call 1-800-CALCOMP or write us at CalComp,
P.O. Box 3250, Anaheim, CA 92803.
In Canada, call (416) 635-9010.

**We draw on
your imagination.™**

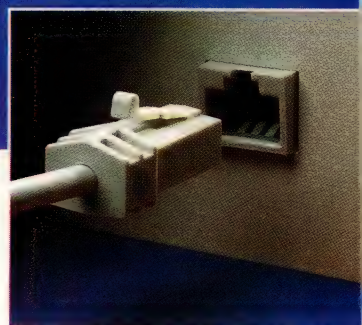




Any color.



Angled or straight.



"Click"—it's connected.

Plug new sales appeal into your system with Du Pont Latch-N-Lok™ Shielded Assemblies.

Improve your system's sales appeal with Du Pont Latch-N-Lok modular interconnections.

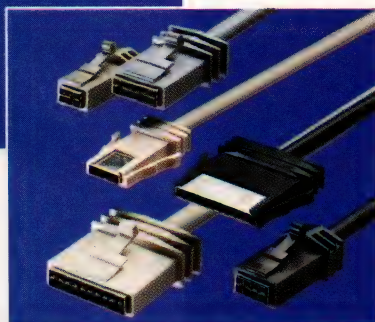
Choose from the industry's widest variety of compact plugs and receptacles. Straight, right-angle or combination designs. Latch on top, bottom or side. Panels, chassis or board mounted receptacles. And cords—coiled or straight—in any length, with any number of conductors, and foil, serve or braid shielding. What's more, Latch-N-Lok can use a variety of wire gauges (22 to 30 AWG) within an assembly.

All of these combinations can be customized and color-coordinated to your system. Yet Latch-N-Lok costs no more than standard assemblies.

And Latch-N-Lok is the only quick disconnect pin-and-socket system. With a contact design proven over millions of applications.

For a free sample or our free brochure call **1-800-237-2374.**

Or write, Du Pont Electronics, Room G-51155, Wilmington, DE 19898.



The smallest package.

Du Pont Electronics
Share the power of our resources.



This High Performance Signal Generator Comes With A Low Sticker Price

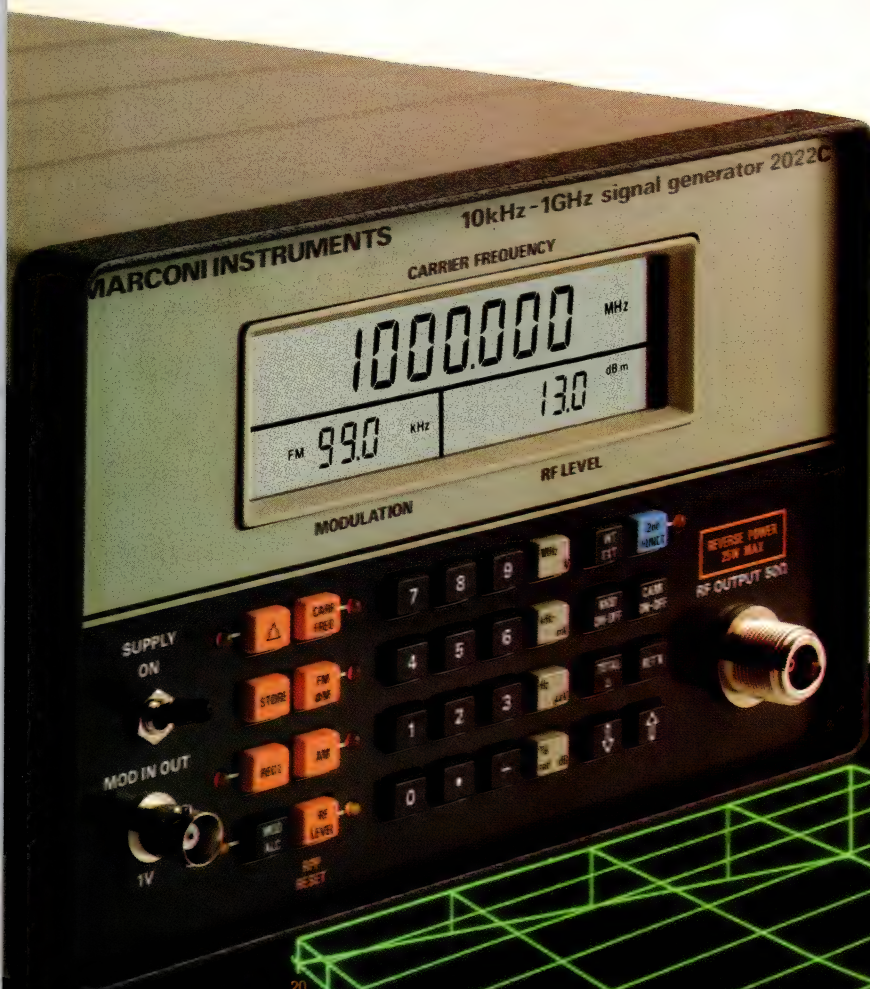
The New 2022C Signal Generator is Loaded With All The Options... +13dBm, GPIB, 2 Year Warranty, and More...

Features like: accurate and level output, setting storage in non-volatile memory, reverse power protection to 50W, memory clear for security. Internally stored status information includes GPIB address, serial no., elapsed operating-time indicator, and the ability to choose from seven calibration display units. All standard.

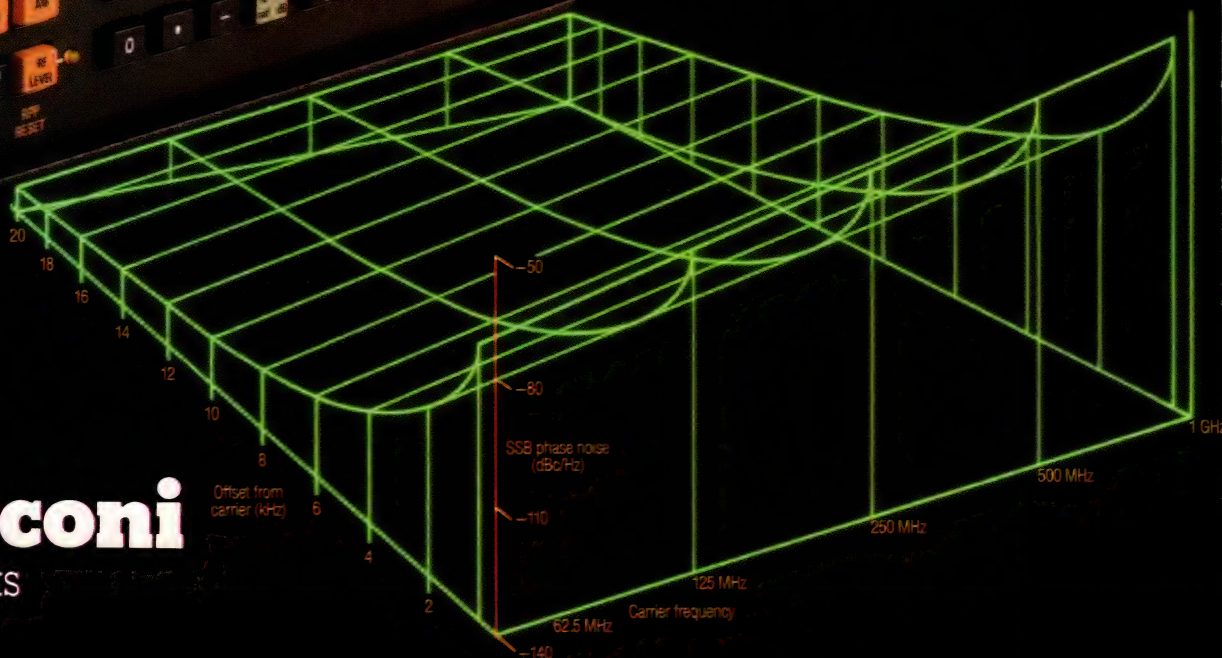
This compact, portable, lightweight unit operates over the frequency range of 10 kHz to 1 GHz.

For a demonstration, literature, pricing contact MARCONI INSTRUMENTS, 3 Pearl Ct., Allendale, New Jersey 07401. 1-800-233-2955 or (201) 934-9050.

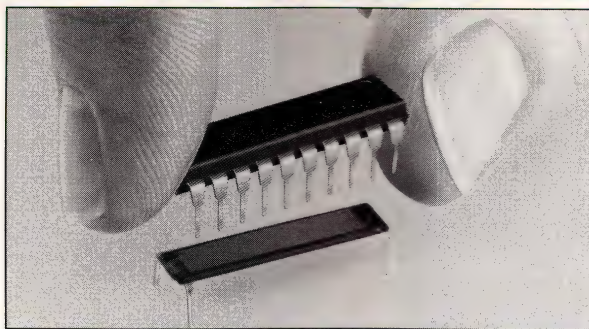
CIRCLE NO 73



Marconi
Instruments



KILL THE NOISE WITH



MICRO/Q[®] CAPACITORS

Reduce voltage noise spikes in ICs by as much as a factor of 10. Without redesign. Without using additional space.

With Micro/Q[®] decoupling capacitors from Rogers. Micro/Q capacitors mount under the IC. Share mounting holes. To improve noise suppression where it's most effective—at the source.

Best of all, Micro/Q capacitors kill the noise without killing a lot of valuable time.

Micro/Q[®] is a registered trademark of Rogers Corporation. Another MEKTRON[®] Interconnection Product.

For all the facts, including the Micro/Q capacitor track record for noise-reduction in dynamic RAMs, EPROMs, static RAMs and boards that need EMI/RFI fix, call a Rogers' Product Specialist today at (602) 967-0624 (Fax 602-967-9385). And ask for a free sample.

Technology for tomorrow built on TQC today.



ROGERS

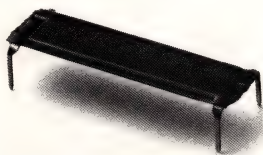
Rogers Corporation
Circuit Components Division
2400 S. Roosevelt Street
Tempe, AZ 85282

DISTRIBUTION: Europe, Japan, Taiwan, Singapore, Hong Kong, Korea, Brazil, Australia

CIRCLE NO 80

MICRO/Q 1000 STANDARD CAPACITORS

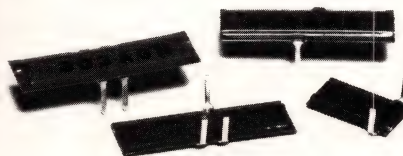
Improve board performance without redesign. Noise problems are solved by retrofitting on existing boards.



CIRCLE NO 81

MICRO/Q 1000 CUSTOM CAPACITORS

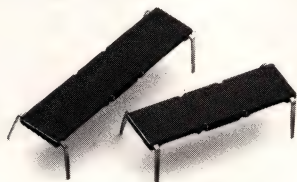
Special pinouts are available to address the wide variety of specialty DIPs such as analog devices, op-amps, and the center pinout advanced CMOS devices. Applications include: decoupling, EMI/RFI filtering, and compensation.



CIRCLE NO 82

MICRO/Q 2000 CAPACITORS

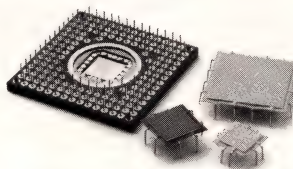
Capacitance levels from 0.01 μ F to 0.3 μ F in Z5V and X7R temperature stable dielectrics. The unique molded construction provides for maximum environmental protection. Suitable for use in both commercial and military applications.



CIRCLE NO 83

MICRO/Q 3000 CAPACITORS

Reduces noise associated with the use of PGA and PLCC devices. Several part sizes are available to address a variety of package sizes. Micro/Q 3000 is designed to be used with all 16/32-bit MPUs, DSPs, GSPs, FPPs, gate arrays, standard cells, and fully custom ASICs.



CIRCLE NO 84



A STEP AHEAD IN THE RACE FOR SPACE

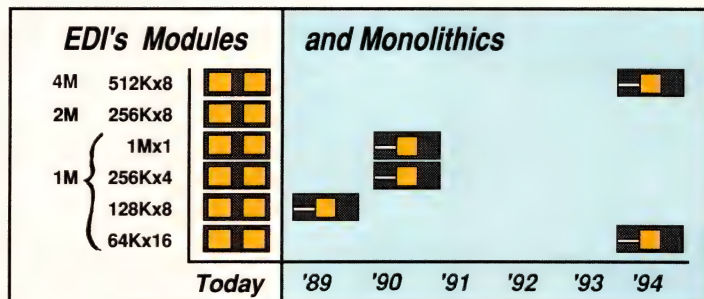
New 1 to 4 Megabit SRAM modules from EDI allow you to design and produce your products with JEDEC standard megabit+ density SRAMs up to 5 years before monolithic technology will be available.

EDI modules are available for both Military and Commercial applications.

1 to 4 Megabit Military modules, incorporating MIL-STD-883 com-

EDI's New Static RAM modules, Military and Commercial, combine today's high performance SRAM technology with innovative packaging to provide 1 to 4 Mbit densities and equivalence to next generation monolithics.

**(Clockwise from Top)
Military 256Kx16, 256Kx4;
Commercial 256Kx8, Military
& Commercial 64Kx16s.**

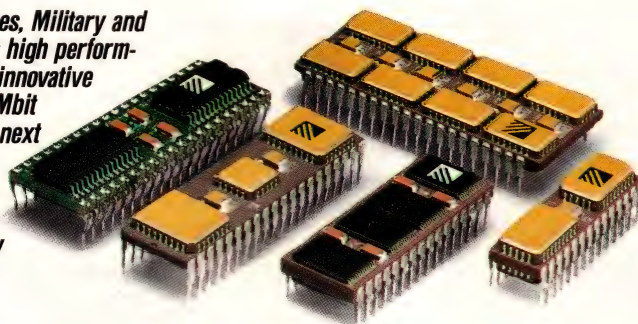


pliant SRAMs in Ceramic LCCs on Ceramic substrates, join the most comprehensive line of high reliability CMOS SRAMs in the industry.

New Commercial SRAM modules incorporate RAMs in plastic V/SOP on Ceramic or FR4 substrates for maximum economy. DIP and SIP packages offer exceptional space savings with densities from 1 to 4 megabits.

Military or Commercial, EDI SRAM modules provide the most effective answer to your space problems, allowing you to provide maximum functional capability in the tightest possible space.

Send for the new Static RAM Module Brochure, from the Industry's Memory Module Pioneer...



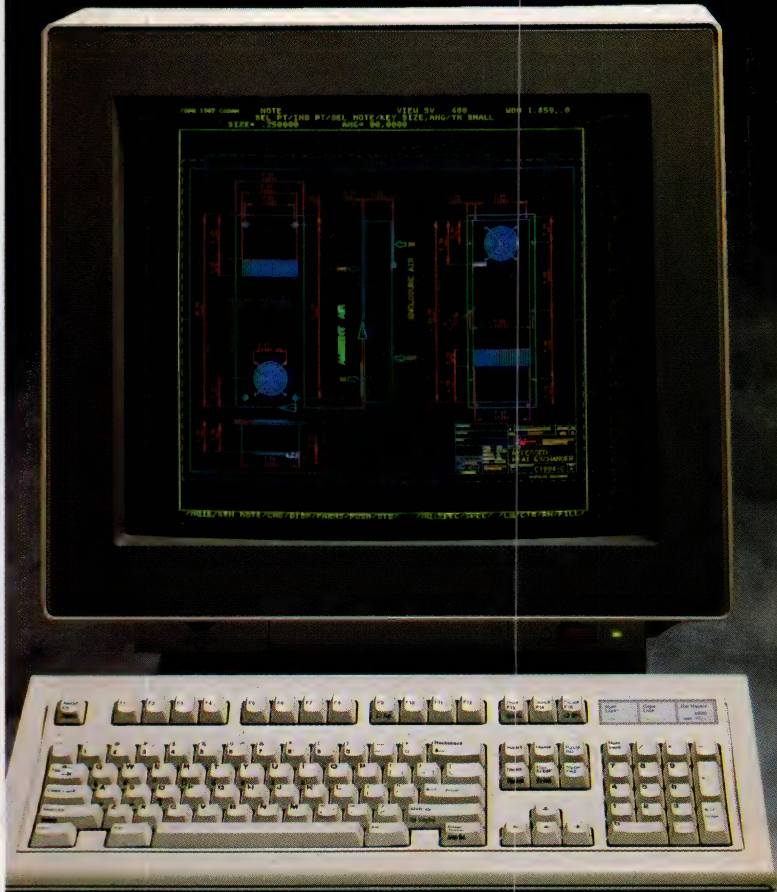
EDI
The future... today.

Electronic Designs Incorporated/42 South Street, Hopkinton, MA 01748/(508) 435-2341/FAX: (508) 4356302/TLX: 948004
Electronic Designs Europe Ltd./Shelley House, The Avenue, Lightwater, Surrey GU18 5RF, UK/0276 72637/FAX: 0276 73748/TLX: 858325

OUR OLDEST BOX.



OUR NEWEST BOX.



We've made some big changes in our inventory.

We've just added a new box. It's a sophisticated computer system that will integrate all ordering, production and delivery functions. It will help us reduce lead times and respond faster to meet your needs.

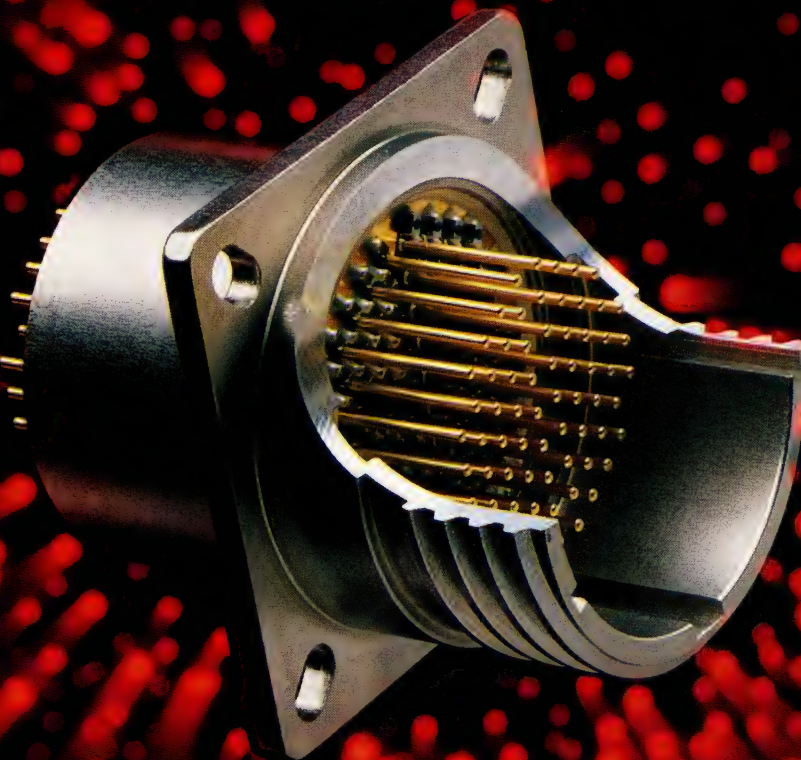
We've also streamlined our inventory to make room for innovative new products. And we've made other important changes, too. They're in our new brochure. For your copy and brief product information, just drop us a line.

Hoffman[®]
ENGINEERING COMPANY

900 Ehlen Drive, Anoka, MN 55303
(612) 421-2240

Circle 7 for Sales Assistance

Circle 8 for Information



**EMP/ESD
protection
without
redesign.**

**Transient-
suppressing
connectors
from AMP**

High-voltage transients — whether an electrostatic charge from the office rug or an electromagnetic pulse from a high altitude nuclear detonation — are certain destruction for small-geometry circuitry.

The vulnerable spot: I/O lines. Conventional protection places clamping diodes on a separate pc board near the connector. This adds to design/redesign requirements, eats up space, and sacrifices response time. In short, you're facing a lot of trade-off.

Unless you look into AMP voltage-suppression connectors. They let you solve ESD problems or meet MIL-Std-461C requirements in the time it takes to install a

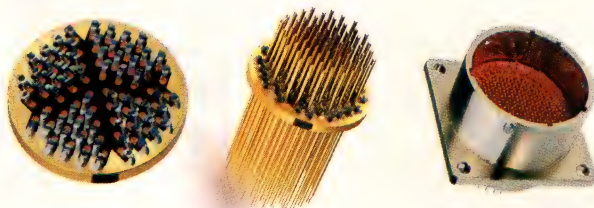
receptacle. No redesign. No lost space. And superior technical performance.

They come with clamping voltages from 6.8 to 100VDC, in a wide range of styles including MIL-C-38999s and MIL-C-24308s. Unipolar or back-to-back zeners are pin-mounted to react in under 5 nanoseconds. Epitaxial silicon design features low capacitance, stable frequency characteristics, and power ratings to beat EMP or ESD energy levels.

Call (717) 780-4400 and ask for the Voltage Suppressing Connector Desk. AMP Incorporated, Harrisburg, PA 17105-3608.

AMP Interconnecting ideas

Pin-mounted voltage clamps offer typical capacitances of 500 pF at 6.8VDC, 100 pF at 30VDC. Peak current capacity exceeds 10A requirements of MIL-Std-461C, peak pulse power is rated at 500W. Available in circular and subminiature D configurations.



Astute designs improve efficiencies of linear regulators

Linear voltage regulators outperform switching-type devices in many applications, but they have one major drawback—poor efficiency. By employing careful design techniques and using new regulator components, you can greatly improve efficiencies.

Jim Williams, *Linear Technology Corp*

Although switching-type voltage regulators are gaining in popularity, linear voltage regulators are still popular devices. Linear regulators are easy to implement and have much better noise and drift characteristics than switchers. In addition, they function with standard magnetics, are easy to compensate, don't radiate RF, and have fast response times. However, linear regulators are saddled with one major drawback—poor efficiency. As a result, they're associated with high operating temperatures and large heat-sink requirements. Linear regulators cannot compete with switching regulators in these performance characteristics, but by using certain design techniques and new linear-regulator devices, you can achieve significantly better results than you might think is possible.

A basic way to improve the efficiency of linear regulators is to minimize the input-to-output voltage across the regulator. The smaller this term is, the lower the

power loss. Manufacturers refer to the minimum input-output voltage necessary to support regulation as the dropout voltage. Different regulator design techniques and technologies offer different regulator performance (see **box**, "Achieving a low dropout voltage"). Conventional 3-terminal linear regulators typically have a 3V dropout, but newer devices feature a 1.5V dropout at 7.5A and a 0.05V dropout at 100 μ A. You can use these new regulators to achieve relatively high efficiencies. However, the overall regulator performance depends greatly on the quality and amplitude of the input signal.

Stable inputs ease problems

Lower dropout voltage leads to significant power savings when the input voltage is relatively constant—that is, when a linear regulator postregulates a switching-power-supply output (**Fig 1**). Here, feedback to the switching regulator stabilizes the main output, A. Output A usually supplies most of the power available from **Fig 1**'s circuit. Therefore, the power demands at the B and C outputs have relatively little effect on the amount of energy in the transformer.

Because of this action, the input voltages to the B and C regulators are relatively constant. Judicious design enables the regulators to run at or near their dropout voltage, regardless of the loading or switcher input voltage. Low-dropout regulators thus save considerable power.

Unfortunately, not all applications boast a stable input voltage. **Fig 2** illustrates a classic situation in which

You can improve the efficiency of a linear regulator by minimizing the input-to-output voltage across the device.

the ac line drives the linear regulator through a step-down transformer. A 90 to 140V ac swing (brownout to high-line range) causes a proportionate change at the regulator input. The efficiencies of standard regulators versus low-dropout devices can vary considerably under such circumstances.

A low-dropout regulator has much higher efficiency on its 5V main output, where dropout figures can be a significant percentage of the output voltage. An efficiency comparison at a 15V output still favors the low-dropout regulator, although the gain in efficiency is not as great as that of a standard regulator. A look at power dissipation under the same output conditions shows that a low-dropout regulator requires less heat-sink area than a normal regulator to maintain the same die temperature. Input voltage variations have a deleterious effect on the efficiencies of both regulators, but a low-dropout regulator clearly cuts power losses.

Fig 3 shows a way to minimize regulator input variations even though the ac line has a wide voltage swing. This preregulator circuit combined with a low-dropout regulator provides high efficiency but still retains the desirable characteristics of a linear regulator.

This circuit servo controls the firing point of the SCRs to stabilize the LT1086 input voltage. IC₁ compares a portion of the LT1086's input voltage to the LT1004 reference. The amplified difference voltage at IC₁'s output drives the inverting input of IC_{2B}. The circuit then compares IC_{2B}'s output to a line-synchronous ramp derived by IC_{2A} from the rectified secondary

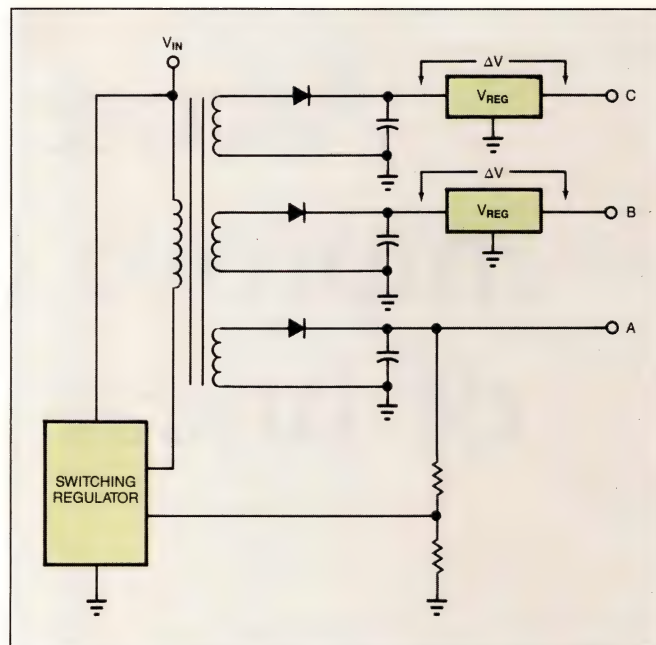


Fig 1—You can realize significant power savings in applications in which the input voltage is relatively constant. In this circuit, a linear regulator postregulates a switching-power-supply output.

of the main transformer, T₁.

The pulse output from IC_{2B} fires the appropriate SCR to develop a current flow from the transformer through L₁. This current flow charges the 4700-μF capacitor. When the transformer output drops low enough, the SCR commutates and charging stops. On

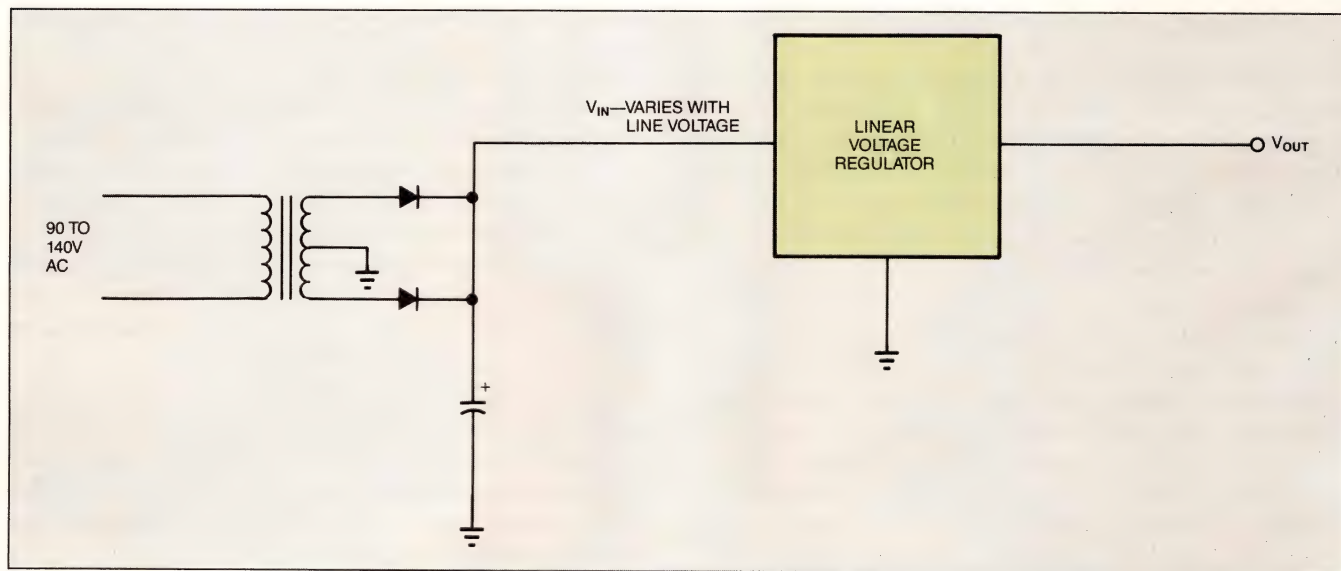


Fig 2—Achieving high efficiencies is difficult when the input to the linear regulator varies in proportion to any line-voltage changes.

Wide voltage variations on the ac-line input have a deleterious effect on regulator efficiency.

the next half-cycle, the process repeats with the alternate SCR doing the work. The loop phase modulates the SCR's firing point to maintain a constant LT1086 input voltage.

The 1- μ F capacitor around IC₁ compensates the loop, and the 10-k Ω resistor at IC₁'s output ensures circuit startup. The 3-terminal regulator's current limit protects the circuit from overloads. This circuit has a dramatic impact on LT1086 efficiency versus ac-line swing. An important note here. The transformer in a preregulator can significantly influence the circuit's overall efficiency. One way to evaluate power consumption is to measure the actual power taken from the ac line.

Fig 4's circuit is useful when an application involves

dc inputs—a regulated or unregulated power supply or a battery. This circuit features low losses at high current levels. The LT1083 functions in a conventional fashion, supplying a regulated output at 7.5A max. The remaining components form a switched-mode dissipation regulator, which maintains the LT1083 input level just above the dropout voltage under all conditions.

When the LT1083 input decays enough, IC_{1A}'s output goes high and increases the voltage on Q₁'s gate. This rising voltage turns on Q₁, which drives current into L₂ and the 1000- μ F capacitor and raises the input voltage at the LT1083 regulator. When the regulator input rises far enough, IC_{1A}'s output goes low, which turns

Achieving a low dropout voltage

Linear voltage regulators almost always use the design illustrated in Fig A for the basic regulating loop. The on-impedance limits of the pass element in the circuit establish the dropout voltage. The ideal pass element should have zero impedance between the input and the output and consume no drive energy.

Different pass elements offer different tradeoffs and advantages in establishing low dropout. Three are illustrated in Fig B. Emitter followers for transistors and source followers for MOSFETs offer current gain and easy loop compensation because the voltage gain is less than unity. They also transfer the drive current to the load. Unfortunately, you have to provide a voltage overdrive at the input to saturate a follower. Since V_{IN} must supply the drive, achieving overdrive is not an easy task. Practical regulator circuits must either generate the overdrive or obtain it from another source. You can easily generate overdrive in discrete regulator designs, but it's hard to do so with

an IC power regulator.

Without voltage overdrive, the saturation loss is set by V_{BE} for bipolar transistors and by the channel on-resistance for MOSFETs. The on-resistance of a MOSFET varies considerably without overdrive, but bipolar losses are more predictable. Note that voltage losses in the drive stages add directly to the dropout voltage parameter. The follower output used in conventional 3-terminal IC regulators combines with the drive-stage loss to set the dropout at 3V.

Common-emitter configurations for transistors and common-source configurations for MOSFETs are another pass-element option. With bipolar devices, the common-emitter scheme removes the V_{BE} loss contribution. It's quite easy to saturate a pnp common-emitter driver, even in IC form. The tradeoff here is that the base current never gets to the load—a situation that wastes substantial power. At higher current levels, base drive current losses can negate a common emitter's satura-

tion advantage. This is a particular problem in IC regulators, where the use of high-beta, high-current pnp transistors is not practical. At moderate current levels, pnp common-emitter drive stages are practical for IC-type regulators—the LT1020 and LT1120 use this approach.

Common-source, p-channel MOSFET configurations don't suffer from the drive-loss problems of bipolars but typically require 10V of gate-to-channel bias to fully saturate. In low-voltage applications, you have to generate negative potentials to satisfy the bias needs. P-channel devices also have poorer saturation characteristics than equivalent-size n-channel devices. The voltage gain available in common-emitter and common-source configurations creates some loop stability concerns, but these concerns are easy to handle.

Compound connections using a pnp-driven npn transistor are a reasonable pass-element compromise, particularly for IC-regulator devices with currents greater than 250 mA. With a compound

off Q_1 and terminates capacitor charging. The MBR-1060 damps L_2 's flyback spike, and the 1-M Ω /47-pF combination sets loop hysteresis at about 100 mV.

Q_1 , an n-channel MOSFET, has a saturation loss of only 0.028 Ω but requires a 10V gate-to-source turn-on bias. IC_{1B} is set up as a simple flyback-voltage booster to provide about 30V of dc boost for Q_2 . Q_2 serves as a high-voltage pullup for IC_{1A} to provide voltage overdrive to Q_1 's gate. This overdrive ensures Q_1 's saturation, even though Q_1 is configured as a source follower.

The 1N966 zener diode clamps excessive gate-source overdrives. These measures are necessary because there are no viable alternatives—low-loss, p-channel MOSFET devices aren't available, and bipolar ap-

proaches require excessive drive currents or have poor saturation characteristics.

Satisfy ultralow dropout needs

In some applications, extremely low dropout is a primary design target. The circuit in Fig 5 is substantially more complex than a 3-terminal regulator design, but it features a 400-mV dropout level at an output of 10A. This circuit uses the same overdriven-source-follower technique employed in Fig 4 to significantly lower saturation resistance.

The LT1072 switching regulator, set up as a flyback converter, generates Q_1 's gate-boost voltage. This 30V boost voltage drives IC_{1A} . IC_{1A} compares the circuit

connection, the tradeoff between the pnp V_{CE} saturation term and the reduced drive losses compared with a straight pnp is favorable. Also, the major current flow is through a power npn—a configuration that's easy to achieve in monolithic form. The compound connection has voltage gain, so you have to pay attention to loop frequency compensation. LT1083-6 regulators use the compound connection for a pass scheme and employ a capacitor at the output to provide loop compensation.

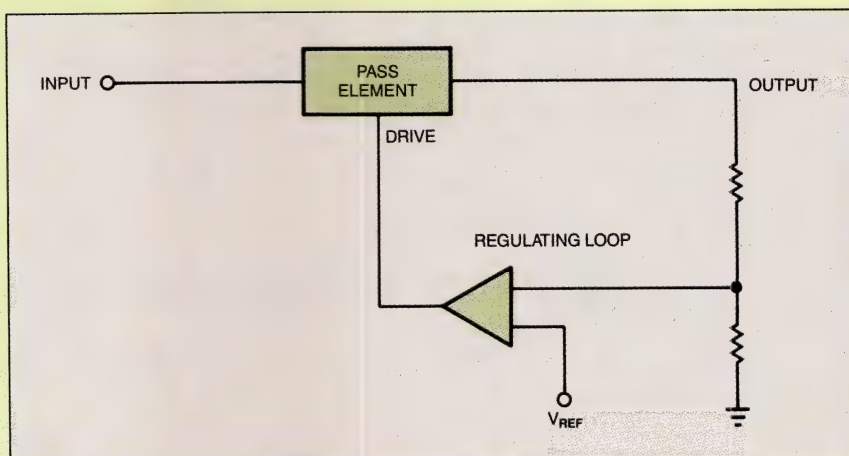


Fig A—Dropout-voltage limitations are controlled by the pass elements used in this basic regulating loop, which is used in just about all linear regulators.

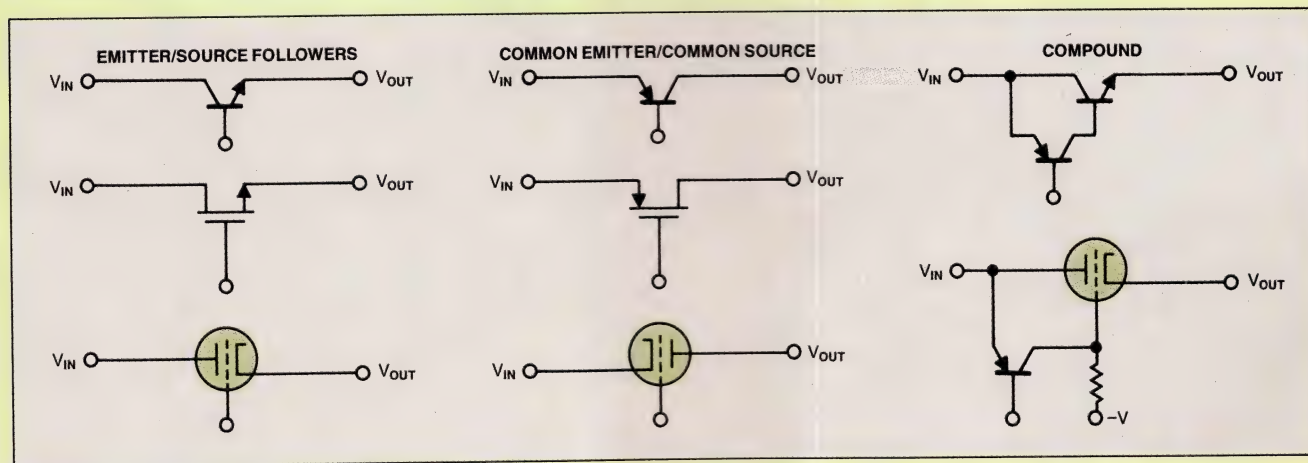


Fig B—These three pass elements offer various tradeoffs and advantages in achieving low dropout-voltage figures.

Power-type regulators can also benefit from low-dropout design techniques.

output to the LT1004 reference and servo controls Q_1 's gate to close the loop.

The gate-voltage overdrive provides the low-dropout characteristic for this regulator by enabling Q_1 to attain a 0.028Ω saturation level. The 1N966 zener diode clamps excessive gate-source voltage, and the $0.001\text{-}\mu\text{F}$ capacitor stabilizes the loop. IC_{1B} senses current across the 0.01Ω shunt to provide current limiting by forcing IC_{1A} 's inverting input to swing negatively. The low-resistance shunt limits loss to only 100 mV at 10A outputs. Circuit roll-off is smooth and evidences no oscillation or undesirable characteristics.

Fig 6 combines the best features of the previous designs to develop a regulator that features high efficiency at high power levels. This circuit combines **Fig 4**'s preregulator techniques with the low-dropout design feature of **Fig 5**. There are, of course, some modifications.

For example, there is no boost supply for the linear regulator, and the 1N967A has a slightly higher zener voltage than the 1N966 in Fig 5. In addition, a single 1.2V reference serves the needs of both the preregulator and the linear-output regulator. The increase in zener-clamp values ensures adequate boost voltage lev-

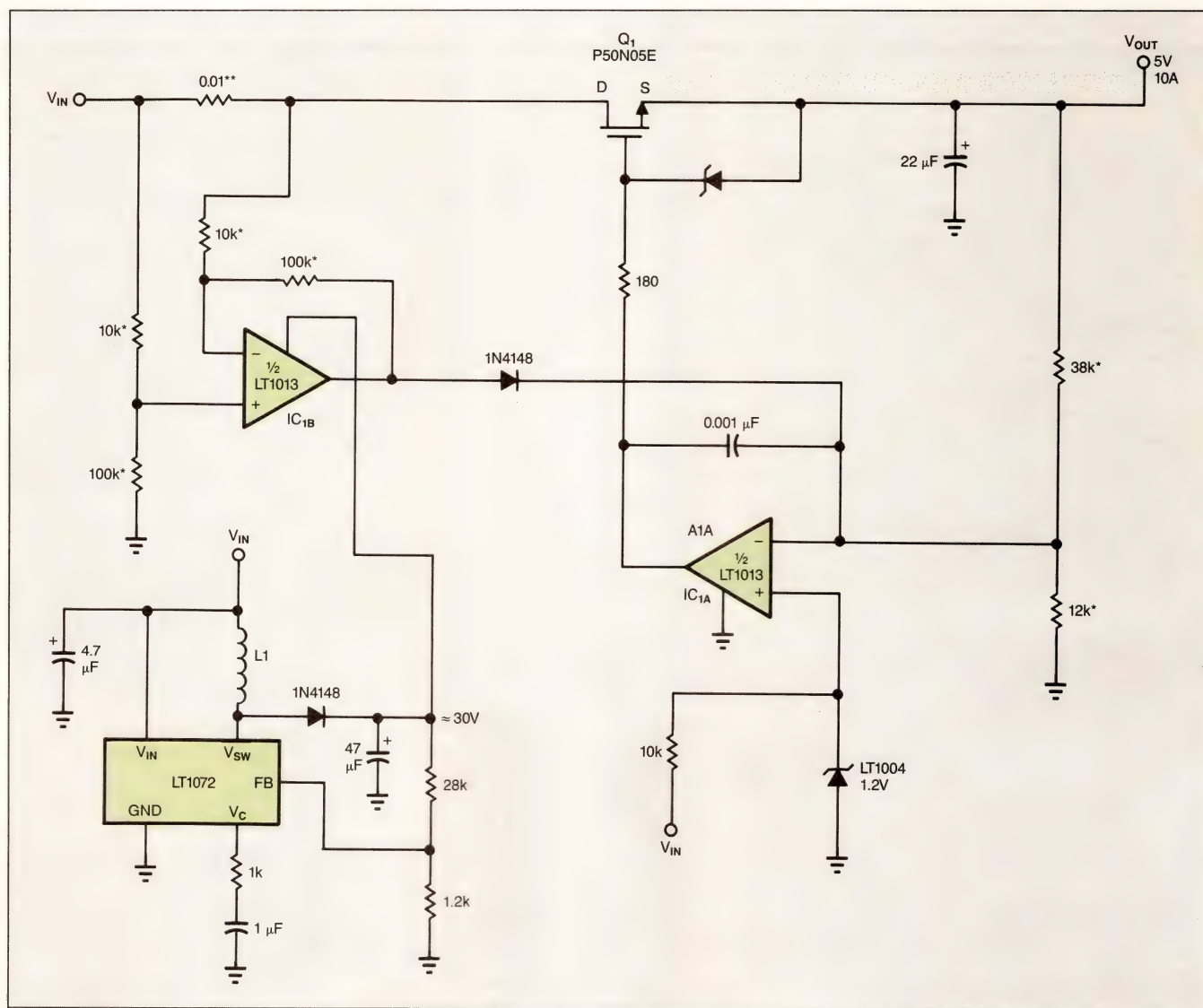
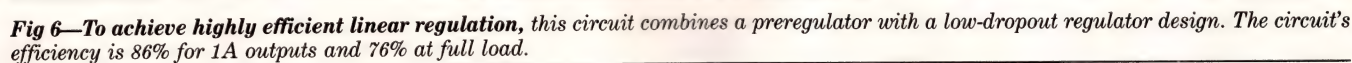


Fig 5—Extremely low saturation resistance is a key benefit provided by the source-follower techniques employed in this regulator. Although it's somewhat complex, the design features a 400-mV dropout voltage at 10A output levels.

Although **Fig 6**'s circuit is complex, its performance is impressive. The circuit's efficiency is 86% at a 1A output level and decreases to 76% at full load. Circuit losses are essentially shared by the MOSFETs and the MBR1060 catch diode. You can improve efficiency by 3 to 5% by replacing the catch diode with a synchronously switched FET and trimming the linear regulator's input to the lowest possible dropout value.

can benefit from the above techniques. **Fig 7's** preregulated micropower linear regulator features excellent efficiency and low noise. A drop at the preregulator's output—pin 3 of the LT1020 regulator—causes the LT1020's comparator to go high. This transition switches the 74C04 inverter chain and biases the p-channel MOSFET on, thus allowing current to flow through the inductor. When the voltage at the junction of the inductor and the 220- μ F capacitor gets high enough, the comparator output goes low and turns off the MOSFET's current flow. This loop action regulates the LT1020's input pin at a value established by the



The on-impedance limitations of regulator pass elements determine dropout-voltage figures.

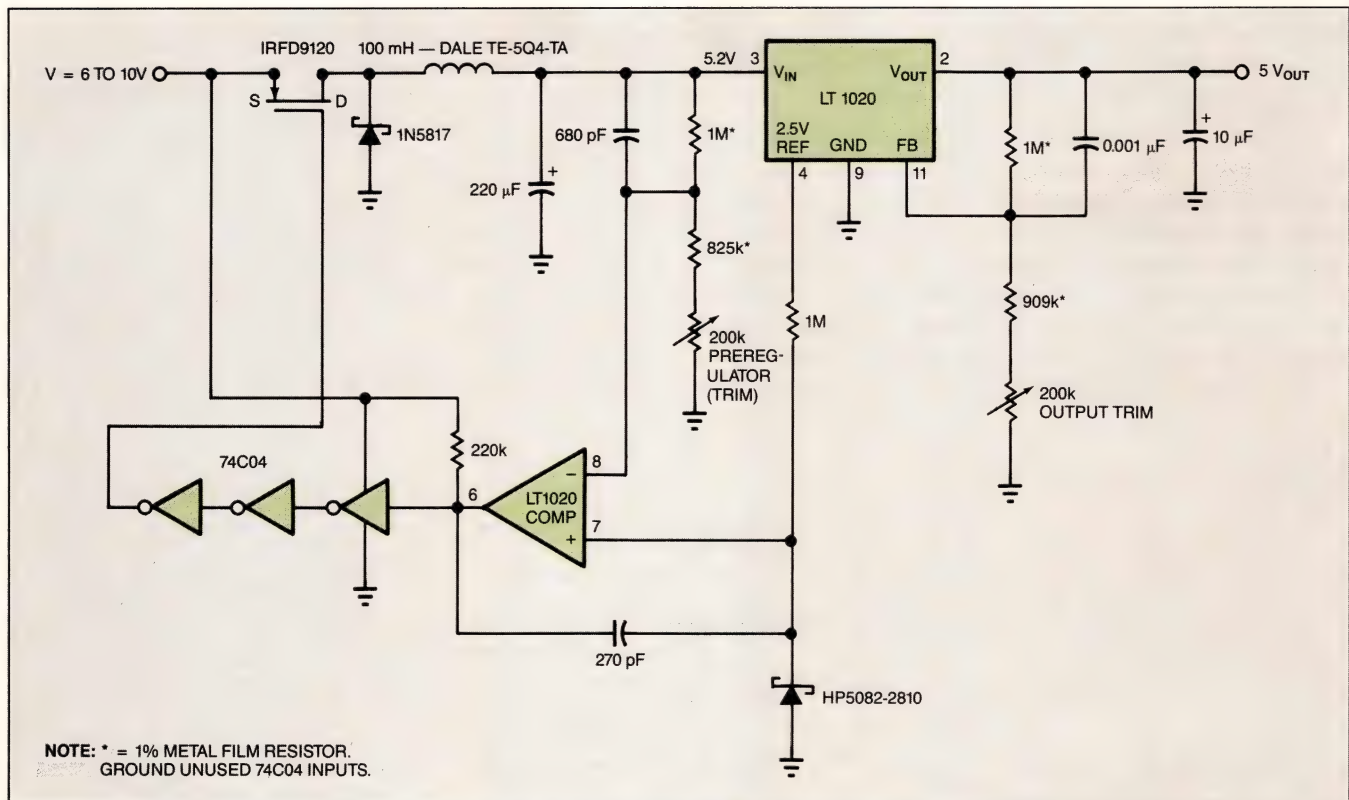


Fig 7—High efficiency and low noise are key features of this micropower regulator circuit. Despite its low, 40- μ A quiescent current drain, the circuit can achieve efficiencies exceeding 80%.

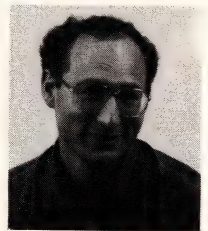
resistor divider at the comparator's inverting input and the LT1020's 2.5V reference. The 680-pF capacitor stabilizes the loop and the 1N5817 serves as a catch diode. The 270-pF capacitor facilitates comparator switching, and the HP5082-2810 diode prevents negative overdrives. The low-dropout LT1020 linear regulator smooths the switched output signal. The output voltage is set by the resistive divider on pin 11.

Start-up poses a potential problem for this circuit. Although the preregulator supplies the input for the LT1020, the preregulator relies on the LT1020's internal comparator to function properly. As a result, the circuit requires a start-up mechanism. The 74C04 inverter chain provides one. When you apply power, the LT1020 sees no input but the inverters do. The 220-k Ω resistive path lifts the input of the first inverter high, thus causing the third inverter to turn on the MOSFET to start the circuit. The inverter's rail-to-rail swing also provides good MOSFET grid drive. The circuit in Fig 7 has a quiescent current level of only 40 μ A and achieves efficiencies in excess of 80% at output levels as high as 50 mA.

EDN

Author's biography

Jim Williams, staff scientist at Linear Technology Corp (Milpitas, CA), specializes in analog-circuit and instrumentation design. He has served in similar capacities at National Semiconductor, Arthur D Little, and the Instrumentation Development Lab at the Massachusetts Institute of Technology. A former student of psychology at Wayne State University, Jim enjoys tennis, art, and collecting antique scientific instruments.



Article Interest Quotient (Circle One)
High 494 Medium 495 Low 496

Take the FREE way to new design innovations

If you're driven to finding the latest ideas, the newest engineering components and the newest design systems, Design™/West is your vehicle for success.

It's the most comprehensive OEM resource on the West Coast—offering you the OEM components and engineering design tools you need to create the most innovative and cost-effective products possible.

Discover thousands of new products for virtually every application—demonstrated and explained

by technical specialists from over 250 leading companies. Find new suppliers who can introduce you to the latest ideas and applications—delivered on time and within your budget!

Get in gear with the Design™/West Conference program. Choose from complete conference programs, valuable workshops and ASME-sponsored professional development courses.

One trip to Design™/West and you'll be on the freeway to innovation. Just bring this ad to the Show. You'll receive *free* Show admission—and save \$25!

Your destination for new design ideas



Free Show admission with this ad



**DESIGN
ENGINEERING
SHOW &
CONFERENCE™/WEST**

September 26-28, 1989
Los Angeles Convention Center
Los Angeles, California

SP

Need information?

Call 1-800-255-7798 (in CT, 203-964-8287)

Our 10th successful year!

CIRCLE NO 87

Power at your command



Military DC/DC Converters +5, +12, ± 12 , +15, ± 15 V Single and dual output

AHE Series DC/DC converters from Advanced Analog have the power and reliability needed for military and aerospace systems.

- -55°C to $+125^{\circ}\text{C}$ and -55°C to $+85^{\circ}\text{C}$ temperature range
- Screened to MIL-STD-883C, Method 5008 in a MIL-STD-1772 certified facility
- 15W and 20W output power
- Hermetically sealed
- Advanced feedback method uses no optocouplers for high reliability and greater radiation tolerance

Now you can get the higher temperature range your system requires. And improved performance. Advanced Analog's AHE Series are built for rugged environments and guaranteed to outperform any other standard DC/DC converter of this type. Other standard Mxx Series converter models are available.

We've got the experience. Our PS Series triple-output, 80W converter is serving in the newest attack helicopter.

Need a special converter or power hybrid? Call us and we'll work with your team to get the best solution for your needs.



DC/DC Converters

	Output Power	Output Voltage (V) Current (A)
AHE2805S	15	5V, 0 - 3A
AHE2812S	20	12V, 0 - 1.67A
AHE2812D	15	± 12 V, 0 - 625mA
AHE2815S	20	15V, 0 - 1.33A
AHE2815D	15	± 15 V, 0 - 500mA

-55°C to $+85^{\circ}\text{C}$ and -55°C to $+125^{\circ}\text{C}$
Input voltage range is 17 - 40V

**MIL-STD-1772
Qualified**

**Advanced
Analog**
a division of Intech

2270 Martin Avenue
Santa Clara, CA 95050
(408) 988-4930

EDN August 17, 1989

RELIABILITY YOU CAN DEPEND ON!



HIGH PERFORMANCE • MIL SPEC

POWER SUPPLIES

COMPLETE AC-DC/DC-DC MULTI OUTPUT SYSTEMS

Rugged, high density power supplies to **8 watts per cubic inch** (including off line front end)...up to 8 outputs and 500 watts per package...efficiencies to 80% plus.

AC INPUT (typical)



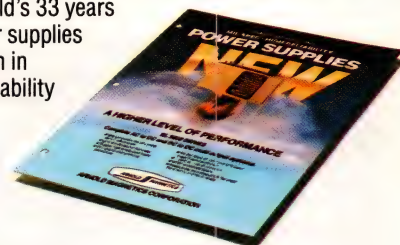
UP TO 8 DC OUTPUTS

CONFIGURE-YOUR-OWN DESIGNS

Choose inputs and outputs from pre-designed standard modules. Non-recurring engineering and qualification expenses are avoided. Deliveries are in weeks not months.

PROVEN PERFORMANCE & RELIABILITY

The no risk alternative to customs...standardized modular designs ensure reliability and reduce the chance of failure inherent in custom circuits and packages. Arnold's 33 years experience in high rel power supplies assures designs field proven in hundreds of tough, high reliability Defense, Aerospace and Industrial Electronics applications.



CALL TOLL FREE FOR OUR EL2000 CATALOG

1-800-421-8181 (in California 805/484-4221)



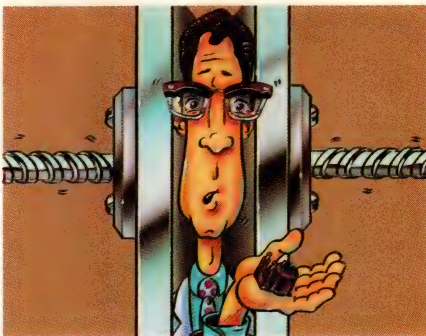
ARNOLD MAGNETICS CORPORATION

4000 Via Pescador, Camarillo, California 93010-5049

Phone: (805) 484-4221 • TWX 910-343-6468 • FAX: (805) 484-4113



Thermal Conductivity



Compression



Contamination



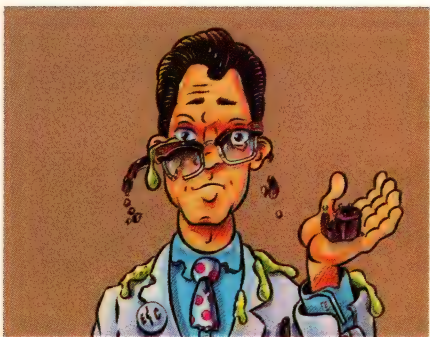
Flexibility.

Our encapsulant guys thrive in a tough environment.

We go through a lot to design the kind of encapsulants that provide superior environmental protection for your electronic components. Just ask our applications engineers. They've put in grueling days developing our epoxy, silicone and urethane technologies. But it was worth it, because E&C has the industry's broadest line of encapsulants. And it's all backed by E&C's sales and technical staff, the finest custom formulations and W.R. Grace & Company's comprehensive R&D network. So what's a few bruises or some singed hair if you're trying to be the best. Find out more. Write or call for our product selector guide, more information and a free poster of our encapsulant engineer. 1-800-832-4929. In MA 617-938-8630.



Thermal Shock



Corrosion



Electrical Conductivity



Lightweight



Vibration

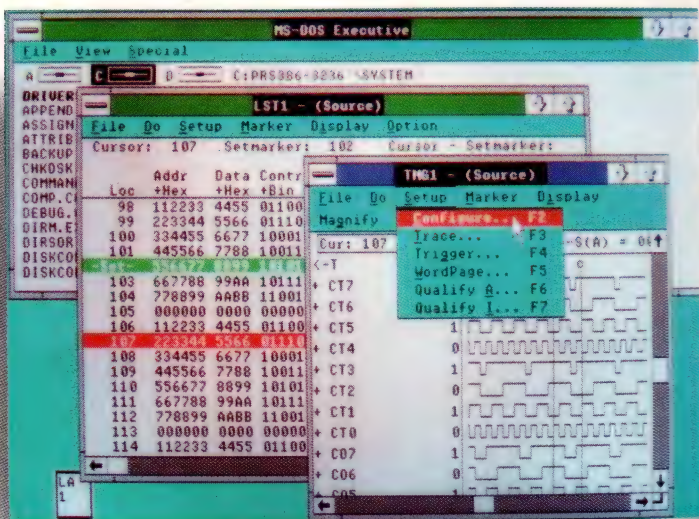
Emerson & Cuming, Inc.
77 Dragon Court/MCD
Woburn, MA 01888

**EMERSON
& CUMING™**
a GRACE company

Making today's products better.
Making tomorrow's products possible.



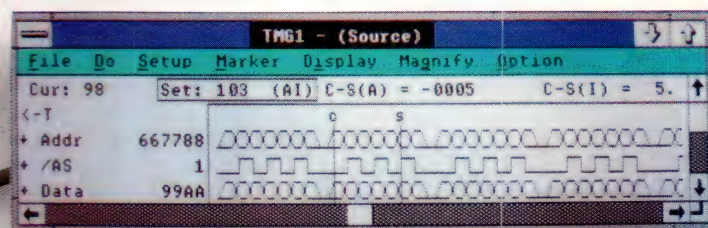
Finally. A High Performance Logic Analyzer That Doesn't Defy Human Logic.



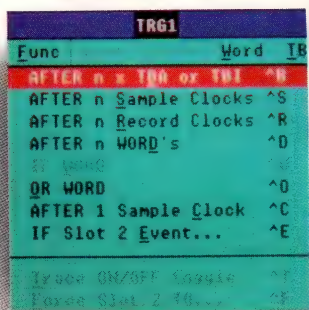
With Microsoft Windows and MS-DOS™, you get full command of the PL1000's power without losing command of your senses.



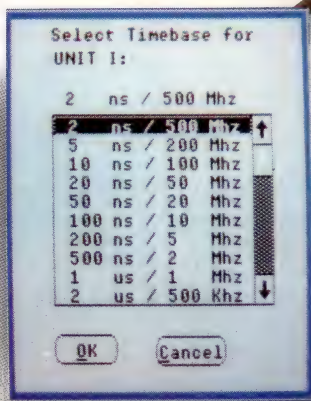
The PL1000 supports disassembly of all popular 8-, 16- and 32-bit microprocessors.



An exclusive clustered channel feature simplifies the display, so you always know exactly where you are on your address bus, at a glance.



Pull-down menus let you click through time base choices, trigger functions, or any other parameters.



Just point and click your way through the first time, and every time.

The new PL1000 makes perfect sense the first time you use it. And doesn't have to be relearned the second time.

You get uncompromised high performance (up to 192 channels at 100 MHz synchronous, or 96 at 200 MHz asynchronous; up to 144 channels at 500 MHz asynchronous, or 72 at 1 GHz) with a friendly, familiar MS-DOS Windows interface.

All the heavy-duty features are here, too. A complete line of application-specific accessories. 100 MHz



synchronous analysis. High performance active probes — 2 MOhm/5 pF. Optional 50-MHz pattern generator.

And you can choose either the PL1000 tower that connects directly to an AT™ computer, or the portable PL1000+, with an integral AT computer.

If you want maximum power with a minimum of aggravation, call today about the new Kontron

PL1000 and PL1000+. The logical analyzers.

KONTRON ELECTRONICS

STC COMPONENTS INC

Turning Possibilities into Realities

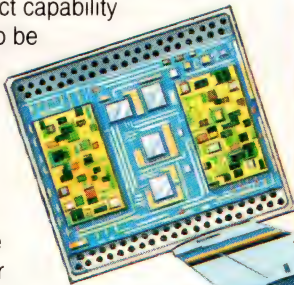
STC Components is a world class manufacturer of high performance custom analogue and digital subsystems and circuits, together with complementary standard product lines.



- **World's first 5V only transceiver.**
- **Low power high speed ECL array.**
- **World wide supplier of high-rel temperature compensated oscillators.**

Military and Aerospace markets demand cost effective system solutions with ever increasing levels of quality and reliability.

STC satisfies these requirements by accepting responsibility from design to "in system operation." Our integrated design and broad product capability permits us to be part of your innovative solution and offers you an opportunity to rationalise your supplier base.

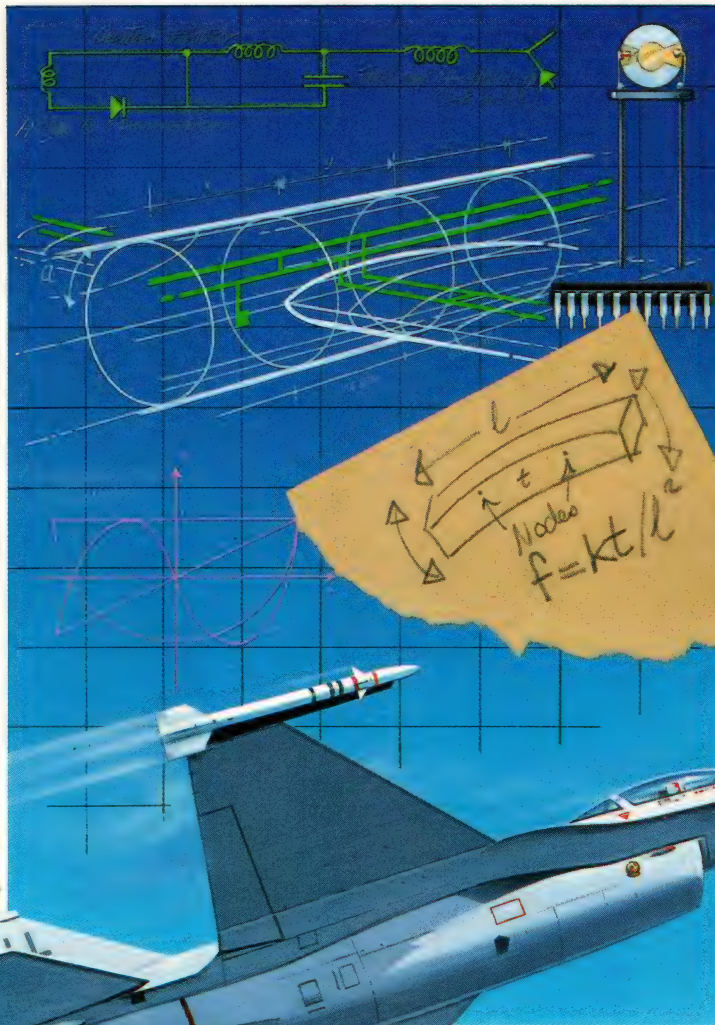


Our strengths come from our expertise in component technology which include advanced hybrid circuits, semiconductors, quartz crystals and power sources.

STC Components is committed to providing a high level of Quality Assurance, manufacturing products to all major international military standards, including BS9000, MIL-STD-1772, AQAP1 and DEF STAN 05-21.

You can enjoy the benefits of this resource by simply filling out and posting the coupon opposite.

STC Components Inc.
636 Remington Rd, Schaumburg
Illinois 60173, USA
Tel: 312 490 7150
Fax: 312 490 9707
Telex: 910 291 1280



Name _____

Address _____

Postcode _____

Tel: _____



STC COMPONENTS

CIRCLE NO 91

EDN081789

Differential techniques move TDR into the mainstream

No longer the esoteric armament of the microwave world, time-domain reflectometry and time-domain transmission now meet a variety of today's troubleshooting needs.

Differential and multichannel TDR/TDT give a complete picture of system and component characteristics.

Jon Lueker, Tektronix Inc

Improvements in TDR/TDT (time-domain reflectometry and time-domain transmission) allow you to quickly make vital component and system measurements that for a long time were difficult to accomplish. For example, you can now purchase instruments that perform differential and multichannel TDR and TDT. By using an oscilloscope that provides these capabilities, you can determine characteristics as diverse as the crosstalk and signal degradation in a ribbon cable, or the input, transmission, and common-mode rejection characteristics of a differential video amplifier.

Although the concepts underlying TDR/TDT technology aren't hard to grasp, if you fail to understand some subtleties—of how the instruments function and how to properly connect a unit under test—you are likely to experience frustration and obtain results of questionable validity.

Time-domain reflectometry is analogous to radar in

that a signal is sent into a component and its reflection is detected; the characteristics of the reflection reveal the characteristics of the component. The signal sent into the component is usually a voltage step, and the shorter the step's rise time, the better. An oscilloscope displays the step's reflection. An equivalent-time sampling scope is now often used for TDR/TDT because, compared with a real-time scope, it can more easily provide the bandwidth and timing resolution needed to clearly resolve the most subtle signal features.

Older test setups often used separate pulse generators and oscilloscopes for TDR, but for reasons of performance and simplicity, the digital oscilloscopes used today for TDR usually incorporate a pulse generator. A TDR/scope combination (the name of the instrument is usually denoted by the same abbreviation as is used for the technique: "TDR" for time-domain reflectometer) can deliver high performance more easily because the manufacturer matches the scope and signal generator and specifies the system's overall response. The Tektronix 11800 digital sampling oscilloscope used in this article's application examples, for instance, provides a 35-psec max system rise time (reflected) when used with Tektronix's SD-24 TDR/sampling head. The step generator itself, though not directly specified, has a rise time typically less than 20 psec.

By comparison, TDR systems assembled from separate high-quality subsystems frequently achieve a much slower system rise time, often in the 500-psec to 5-nsec range. The slower response results in less information about the unit under test. This shortcoming becomes especially apparent when testing systems

Time-domain reflectometry is analogous to radar in that a signal is sent into a component and its reflection is detected.

that must deal with rise times shorter than 1 nsec (for example, ECL or GaAs logic systems).

By detecting the signal that passes through the component, rather than the signal's reflection from the component, you can use the same oscilloscope for TDT as well as TDR. Thus, TDT takes advantage of the same high-performance equipment used for TDR to determine such parameters as the gain of an amplifier, the attenuation of a pad, the loss of a ferrite bead, or the value of an inductor.

See the meaning in TDR traces

TDR and TDT display their results in the time domain. Specifically, the TDR traces you see on the oscilloscope show impedance variations as the step travels through the component under test. Because the time required for the step to go out from the scope and reflect back equates to distance, you can tell where impedance variations occur. For example, the first major reflection on a TDR trace might correspond to the point where the cable from the scope is soldered to a

pc-board trace. This reflection is due to the mismatch between the impedance of the coaxial cable, which connects the scope to the board, and the impedance of the circuit trace being characterized.

The height of the reflection from the coax-to-pc-board transition shows the impedance of the pc-board trace. To understand what the height means, note that the reflection from an open circuit (such as an unterminated length of wire) appears as a positive step; the reflection has the same amplitude as the incident step (Fig 1). In contrast, a step reflected from a short circuit (a wire connected to ground) shows up as a negative reflection of the same amplitude as the incident step. Between these extremes, positive and negative voltage steps indicate differing impedance levels. The expression

$$2 \cdot \rho = (Z - Z_0) / (Z + Z_0)$$

predicts the reflection height (ρ) when a signal passes from a line of impedance Z_0 to a line of impedance Z .

A further bit of information you can get from a TDR trace is the inductance or capacitance associated with a component. Whereas rectangular features in the TDR trace indicate line-impedance changes, exponential features indicate a lumped inductance or capacitance. The time constant associated with the component produces the exponential shape, and you thereby have enough information to quickly calculate the inductance or capacitance.

The ability to determine specific impedance at any point in a circuit can be important in many applications. Perhaps more important, though, is the intuitive feel you get from seeing the TDR trace's variations. The trace shows any potential problem areas at a glance, in contrast to the hit-or-miss methods that are commonplace without TDR. In fact, when TDR is not available, problems with impedance mismatches can come to light only when a circuit does not work correctly. For example, an intermittent glitch on a TTL backplane caused by poor signal interconnection might take hours or even days to track down using traditional methods; TDR often reveals such problems in minutes.

You can get similar information about a system by using a network analyzer. These instruments are primarily useful for characterizing input and transmission parameters in the frequency domain, and they produce their results in the form of frequency-domain data. For most logic-design work, however, you think about problems in the time domain and you may conclude

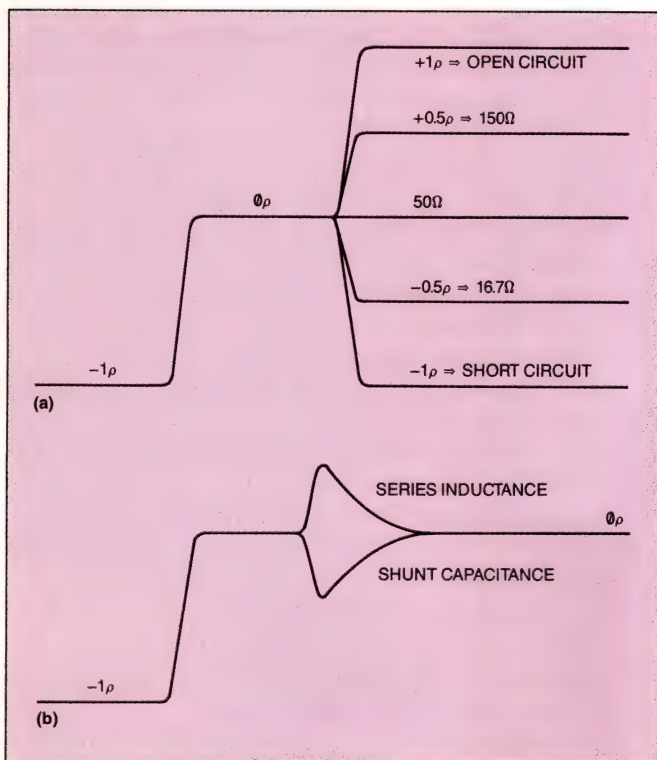


Fig 1—Discontinuities in the impedance of a transmission line show up as upward and downward steps (a) in a TDR display. Lumped inductance and capacitance (b) appear as decaying steps from whose time constants you can calculate the lumped-element values.

that the convenience of differential and multichannel TDR removes many of the reasons for avoiding time-domain measurements when working with logic.

Single-ended TDR meets traditional needs

The simplest type of TDR has one single-ended channel. In this case, the TDR unit sends one step into one input of the unit under test and captures the reflections from that same input. This type of TDR has been used for many years for testing high-performance cables, connectors, and pc boards. TDR was used mainly for characterizing the latter two component types for RF and microwave work. TDR cable testing generally involves communication lines spanning longer distances, from yards to miles. During both installation and maintenance, cables are checked with TDR to ensure that the cable, with its splices and taps, passes signals cleanly.

Single-ended TDR/TDT has found a growing number of applications as digital systems get faster. However, many high-speed signals that must propagate for any significant distance (even just a few inches at high frequencies) are transmitted differentially to preserve signal quality. Obtaining valid differential results with

a single-ended TDR system is difficult in many cases—and is occasionally impossible. In general, simple addition of single-ended TDR values does not give differential results; if you use single-ended TDR in a differential system, you must be careful to properly apply Thevenin's theorem when converting from differential to single-ended configurations. Furthermore, you must usually make at least two single-ended measurements to obtain the data you could obtain from one differential measurement. Single-ended TDR/TDT thus can have frustrating limitations for digital designers, who are increasingly using such structures as twisted pairs, ribbon cables, and coupled lines to transmit their critical differential signals, and who are often under intense time constraints.

The explanation of the complexity of obtaining differential results with single-ended TDR calls forth some involved transmission-line theory. You can quickly grasp the underlying reasons, however, by examining the nature of a differential line (Fig 2). Such lines usually have a ground structure and two signal conductors, which carry differential (complementary) signals. The fields generated by the complementary signals tend to couple the signal lines directly, rather than simply coupling each line independently to ground. Differential lines have two great advantages. First, at a distance from the lines, fields tend to cancel out, leaving very little radiated EMI or RFI that could cause problems elsewhere (in the form of crosstalk, for example). Further, the differential signals tend to shrug off external noise because each line senses the noise equally; this common-mode noise is not detected by the differential receiver, which senses only the difference between the complementary signals.

The reason why single-ended TDR can fail to work with differential lines lies in the interaction between the complementary conductors. If you only excite one of these conductors, the transmission effects differ greatly from those you see when both conductors are interacting differentially. If a twisted pair suspended over a ground plane is excited differentially with steps at $\pm V$, only the differential mode of propagation is excited and then measured. You can think of a single-ended TDR pulse of amplitude $+V$ driving only half of the pair as the sum of the differential excitation of $\pm V/2$ and a common-mode excitation of $+V/2$ (on both conductors). This combination simultaneously creates differential and common-mode signals, which can have different impedances and propagation velocities. The resulting display on the instrument screen can be a

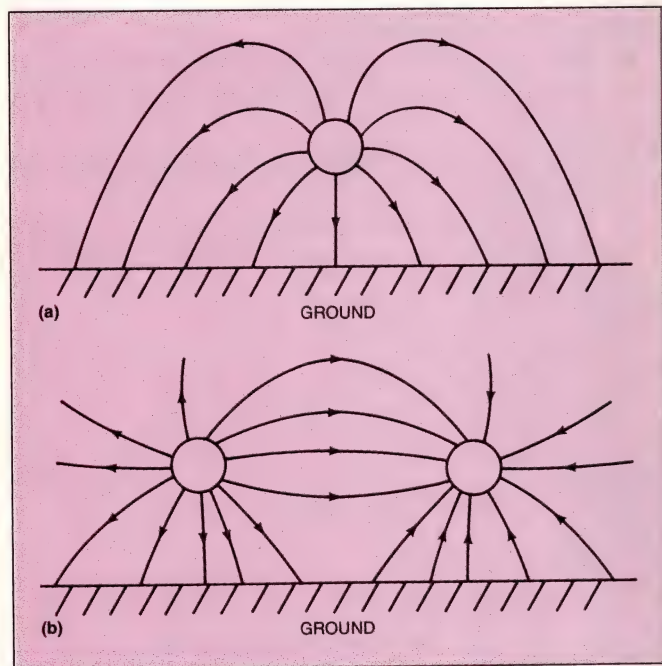


Fig 2—The electric fields surrounding a conductor carrying a single-ended signal (a) are much different from those in the vicinity of a pair of conductors (b) carrying a differential signal. The differences help to explain why you must use care in applying single-ended TDR to differential systems.

The same oscilloscope used for TDR can be used for TDT by detecting the signal that passes through the component rather than the signal's reflection from the component.

complex waveform that masks the useful information. If you are working with differential lines, you'll probably find that differential TDR/TDT makes your life a lot easier.

Differential TDR/TDT is really a special case of multichannel TDR/TDT in that a differential test requires step generation and signal acquisition on two channels. Each channel must have the flexibility to generate a step in the positive or negative direction so that you can set up the necessary complementary signals for differential testing. By using positive-going or negative-going steps on both differential channels, you can also check a differential component's response to common-mode signals.

Moreover, there are benefits to having four or even more TDR/TDT channels. With four channels, for instance, you can simultaneously perform differential TDR and TDT, or perform differential TDR while checking for crosstalk on another differential line.

More than four TDR/TDT channels can prove invaluable for automatic test equipment (ATE) use. In a high-speed chip tester, for instance, a large number of TDR channels assists in deskewing signal lines precisely—an operation that high-throughput TDR handles in seconds, compared with the hours of work cable characterization can require.

Two typical application examples, with tips for obtaining good results, illustrate the usefulness of differential and multichannel TDR/TDT. In these examples, TDR/TDT sheds light on design factors that have long plagued digital circuits. Crosstalk, for example, has long been difficult to predict and control. You generally

discovered crosstalk only when your circuit began to fail intermittently. And even then you could only guess that crosstalk was the culprit. Multichannel TDR/TDT provides a quick way to quantify crosstalk and other potential problems.

The first application example involves a 2m-long, 20-conductor ribbon cable that connects two synchronous digital circuit boards. The cable carries eight bits of bidirectional data plus a clock and a data signal generated by one of the boards. (Though use of such a long ribbon cable to carry high-speed digital signals is an example of a questionable design practice, it represents a situation that occurs all too frequently.) A wire mesh covers one side of the cable for ground purposes; pin 1 connects to this ground mesh. The cable manufacturer may furnish performance specs for the bare cable, but when you add connectors, the cable's characteristics can change dramatically.

The clock is the most critical signal carried by the cable because any variations in the clock waveform can mean that data is not strobed into latches correctly. (Setup and hold times for the data and direction signals prevent problems on those lines.) For a high-speed TTL or ECL system, there are several potential design problems you must investigate:

- Will the ribbon cable pass the clock without rounding off the corner of its rising edge too much?
- Will reflections in the ribbon cable disrupt the clock?
- Will crosstalk cause problems under some circumstances?

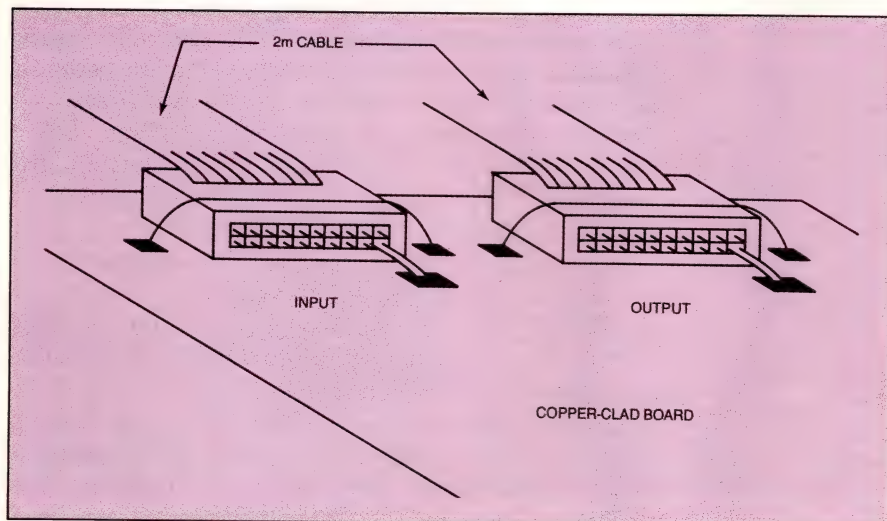


Fig 3—When you apply TDR to a ribbon cable, you need to make sure that the ground connections between the cable and your pc board are as short as you can make them. This same rule applies to the signal and ground connections between the cable connectors and the TDR instrument.

- Should you use a differential line for the clock to ensure correct operation?

If you have answered one or more of these questions in the affirmative, you would be wise to make all the measurements differentially.

A simple setup plumbs a ribbon cable

An easy way to make these measurements is to fasten the connectors on both ends of the cable to a piece of copper-clad board (Fig 3). You can do so with glue or by soldering a wire across each connector, orienting the connectors so that the pins are parallel to the board. Insert a pin into socket 1 of each connector and solder the pins to the board. Be sure to keep these ground pins as short as possible.

This simple arrangement allows you to make all the necessary measurements in an environment that simulates an actual board-to-board connection. For convenience, one connector on the cable shown in Fig 3 is labeled as the input and the other connector as the output. You insert TDR pulses into the input connector; you monitor TDT results at the output connector.

You can make connections from the scope to the ribbon cable using 50Ω coaxial cable with a pin soldered to the cable's center conductor. Gather the coax's

ground braid to one side and leave it dangling. You can now insert the pin into any of the connector's sockets and tack solder the coax's ground braid to the board. It is crucial to keep both the signal pin and ground connection from the coax as short as possible—no longer than about 0.2 in. If possible, the coax should touch the connector when you insert the pin. When you move the coax from socket to socket, move the ground braid too, so that you always minimize the length of the ground connection.

To perform single-ended TDR on wire 2 of the ribbon cable, insert the coax pin and tack down the braid. Then run the scope's procedure for TDR. In the Tektronix 11800 scope, pop-up menus lead you through the set-up procedure and allow you to display results in terms of either millivolts or the reflection coefficient, ρ . The latter is the traditional unit for TDR and is based on the amplitude of the TDR step pulse. The amplitude of the step itself equals 1ρ , with all other amplitudes normalized to this value. Because ρ bears a mathematical relationship to impedance, you can use it in determining the impedance of a network at any point. The relationship for impedance is

$$Z = Z_0((1 + \rho)/(1 - \rho)),$$

where Z_0 is the characteristic impedance of the system. For the set-up described here, Z_0 equals 50Ω.

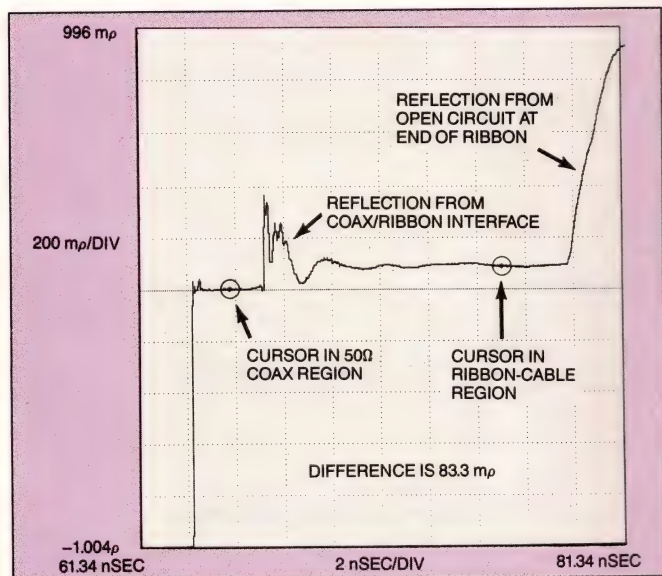


Fig 4—If the impedance of a pc-board trace is slightly greater than that of a coaxial cable that brings a signal to the board, the TDR display will show a small positive step. The large step at the far right is the result of an open circuit at the end of the pc-board trace, and the "pulse" that precedes the small step is the result of an impedance discontinuity where the cable joins the board.

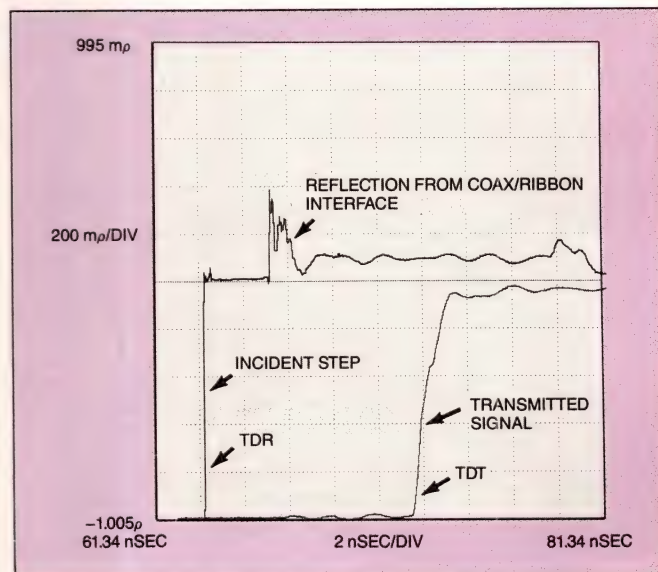


Fig 5—A TDT trace superimposed on a TDR display shows how passing a step through a cable modifies the step.

Because the time required for the step to go out from the scope and reflect back equates to distance, you can tell where impedance variations occur.

The TDR trace from the ribbon cable (Fig 4) shows the incident step leaving the sampling head (the first rise), entering the connector (the jumbled-looking part of the trace), and reflecting from the ribbon cable's open end (the second rise). You can determine precisely where the step enters the connector by using a screwdriver to short the wire at this point; the TDR trace will show a negative step at the short. With this reference point established, you can measure the precise electrical length of the cable. The time between this reference point and the positive reflection from the cable represents the "down-and-back" time of the cable itself. The electrical length of the cable is thus one half of that time.

Because the part of the TDR trace representing the step's passage through the ribbon cable is higher in amplitude than zero ρ , you can tell immediately that the ribbon cable's impedance is somewhat higher than 50Ω . Using the formula given above, the ribbon cable's impedance is

$$Z = 50\Omega((1 + \rho)/(1 - \rho)) = 50\Omega((1 + 0.0833)/(1 - 0.0833)) = 59.12\Omega.$$

You can also detect the lumped inductance introduced by the connector. The short exponential and subsequent ringing at the coax/ribbon interface repre-

sent the inductance of the ground return due to the fact that all the ground currents must converge on pin 1 of the connector. This shared ground will also prove to be the most serious source of crosstalk.

Knowing the ribbon cable's exact impedance shows you the load your circuitry must drive. The cable's impedance also establishes the termination resistance you must use to match the cable, and thus minimize electrical reflections.

To see how the cable affects a step passing through it, you can use TDT (Fig 5). With a multichannel scope like the 11800, you use one TDR channel to insert a step and another channel in acquisition mode to detect the pulse when it emerges from the ribbon cable's output. Using a second channel of matched characteristics for receiving the TDT signal ensures that the system is well matched. Note that you can simultaneously execute the TDR and the TDT tests—which is also what you do on separate wires to perform the crosstalk test. Specifically, you insert a TDR step in one wire and use TDT to detect the signal induced on another wire.

To get a complete picture of the ribbon cable's crosstalk, you must determine the contribution of each wire in the cable. If, for example, you use wire 2 for your clock line because it is nearest the ground pin, you can expect wire 3 to contribute the most crosstalk, with other wires contributing less as the distance from

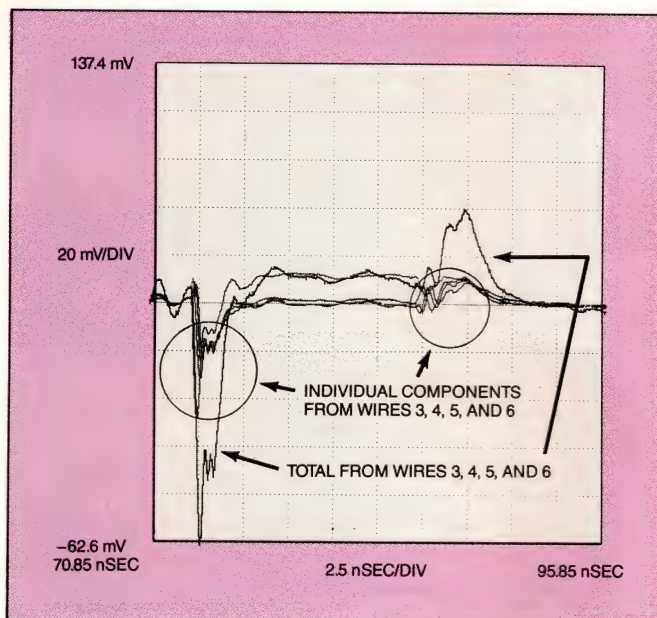


Fig 6—Using multichannel TDR and the scope's ability to add waveforms, you can observe how crosstalk from several signal lines affects a sensitive signal line.

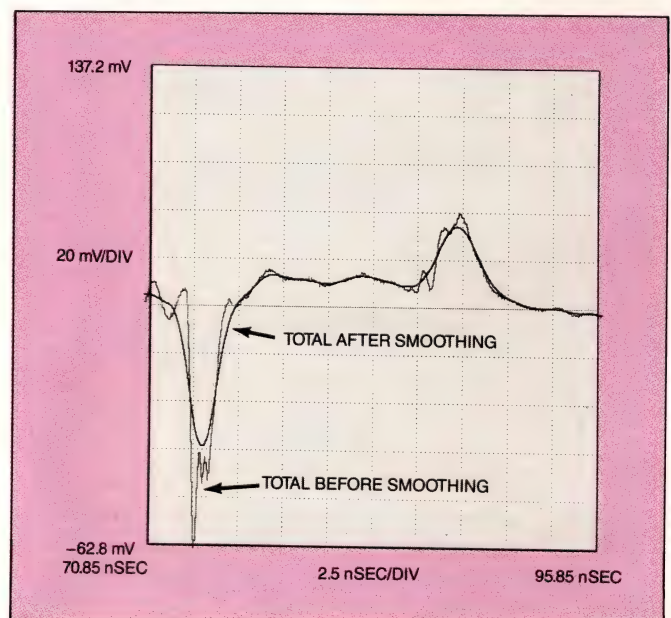


Fig 7—The scope's lowpass filtering or smoothing capability makes it possible to observe crosstalk effects only in the range of rise times that are significant to the logic family you are using.

wire 2 increases. The rule of superposition says that you can add such electromagnetic contributions arithmetically to determine the total signal, as long as you maintain representative source and receiver impedances at the cable's ends.

To check crosstalk on the clock line, you can therefore put a step pulse into each data wire in turn, while measuring any signal coupled to wire 2. The digital sampling scope can record each TDT waveform and automatically sum them, presenting you with a picture of worst-case crosstalk. The results appear in Fig 6.

The crosstalk shown in Fig 6 is induced by an extremely fast pulse. Even GaAs logic is unable to equal this pulse's 15-psec rise time. Slower signals will induce less crosstalk, but you need to determine how much less. To do so, you use the sampling scope's filtering feature to slow the TDR system rise time to show only results that are relevant to the logic speeds you are using.

For example, if you're using high-speed TTL, you might wish to use a TDR system with a 2-nsec rise time to approximate the actual signals in your system. If the scope contains a bandwidth-limiting filter, you will be able to select the scope's rise time and directly characterize structures with relevant signals.

Fig 7 shows the total crosstalk, again with filtering applied, and indicates that crosstalk is still a problem

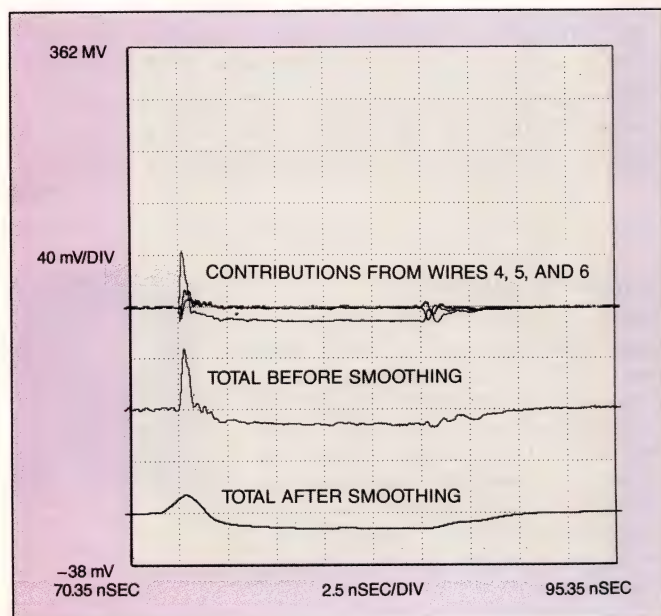


Fig 8—Using the ribbon cable's conductors as differential pairs greatly reduces the crosstalk, as these differential TDR traces readily show.

even at TTL speeds. Note that even after filtering to logic speeds, there is a peak in the crosstalk signal of roughly 25% of the voltage swings on the driven channels, a clear violation of system noise-margin requirements.

The amount of crosstalk on the clock wire makes it clear that a differential clock line is a wise choice. To make sure that a differential line will be adequate, you can check wires 2 and 3 differentially for crosstalk. Fig 8 shows the crosstalk test again, except now you measure the induced signal on lines 2 and 3 differentially. Note the dramatic reduction after smoothing: The peak crosstalk is only 4% of the total voltage swing on the driven lines.

Another application example involves an active device—a differential linear amplifier. The specific device used in this example is a 10H116 ECL line receiver, which can be used as a linear RF amplifier at low signal levels, despite its logic-device label (Fig 9). The measurements described for this chip are useful for any high-speed differential amplifier.

The first test is to use differential TDR to determine the amplifier's differential input capacitance. To do this, you apply complementary input steps to the two inputs and examine the time constant of the reflected signal. (The SD-24 TDR/sampling head offers adjustable step amplitude, which permits a measurement within the linear input range of the 10H116.) Note that by using true differential TDR, you measure the

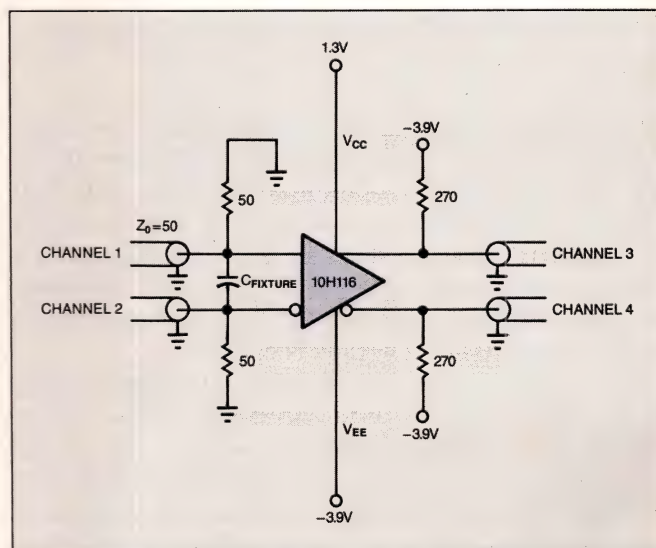


Fig 9—The setup for measuring the common-mode rejection of this differential ECL line receiver is straightforward—at least at the schematic level.

The time constant associated with the component produces the exponential shape, and gives you enough information to quickly calculate the capacitance or inductance.

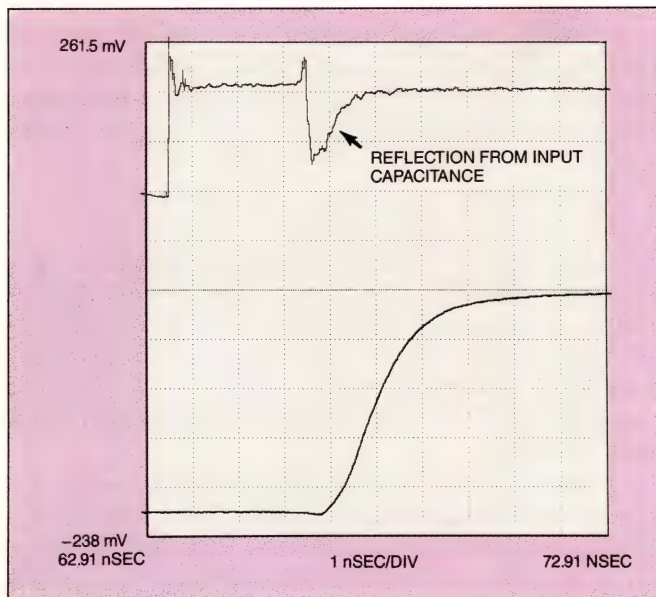


Fig 10—Applying a 20-mV differential step to the 10H116's input, as seen in the upper TDR trace at 10 mV/div, produces a differential output of approximately 200 mV, as seen in the lower TDT trace at 50 mV/div. In other words, the line receiver's gain is approximately 10. The lower trace also reveals a rise time of about 2.1 nsec.

actual differential input capacitance of the chip; this value is somewhat higher than the combination of the two separate input capacitances measured with a single-ended TDR. As shown in **Fig 10**, the time constant is 400 psec, so

$$C = \text{Time}/R = 400 \text{ psec}/50\Omega = 8 \text{ pF (including test socket)}.$$

The second test, the characterization of the chip's output response, follows easily from the first. If you are already applying a differential input that falls within the 10H116's linear region and your scope has an additional pair of acquisition channels, you can use them to examine the differential step at the chip's output. As you can see in **Fig 10**, the differential gain is roughly 10, and the rise time is 2.1 nsec.

One more test you can perform on the line receiver is to check how well it rejects common-mode noise. You do this by presenting the chip with a pair of step pulses of the same orientation, rather than the complementary pulses used in differential signals. Any corresponding signal on the chip's outputs indicates the device's susceptibility to common-mode noise. **Fig 11** indicates that the 10H116 has an excellent common-mode rejection ratio, even when driven with very high-speed

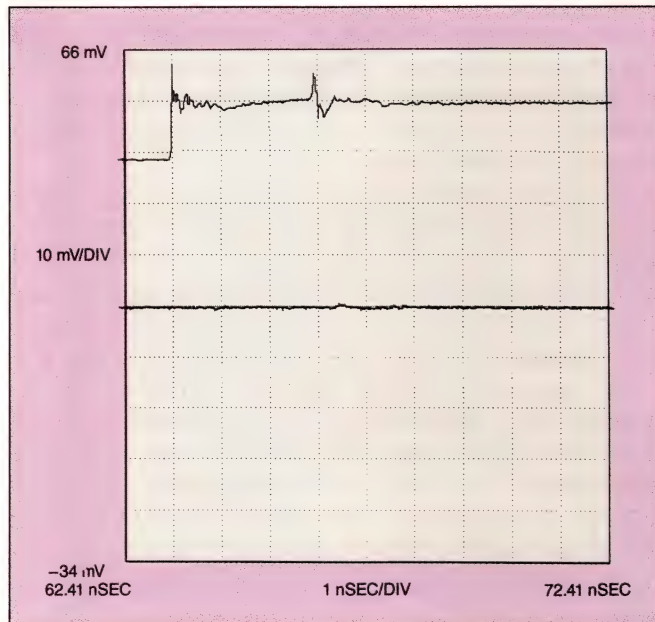


Fig 11—Stimulating the 10H116 with a purely common-mode step (upper trace) produces very little output (lower trace), an indication of excellent common-mode rejection at all frequencies of interest.

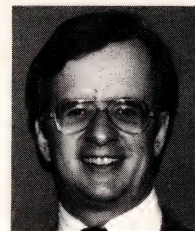
common-mode inputs.

Many engineers will agree that before the advent of differential and multichannel TDR/TDT, some of the tests described here were impractical or even impossible. For example, a single-ended crosstalk test requires that you apply pulses and monitor signals at different points, something you can't do with a single-ended, single-channel TDR. As logic speeds continue to increase, differential TDR/TDT techniques are likely to become a requirement for large numbers of designers.

EDN

Author's biography

Jonathan Lueker is project leader for high-frequency sampling head development at Tektronix Laboratory Instruments Div in Beaverton, OR. He has been employed at Tek for over 7 years, and among the products for whose development he has been responsible is the SD-24 sampling head. Jon holds a BSEE from MIT. In his spare time, he enjoys traveling, skiing, bicycling, and carpentry.



Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493

At last, a real breakthrough in PLD design

What would the perfect PLD design software include?

Some problems are better solved using truth tables. Others could use a procedural language for state machines. Boolean equations are certainly necessary. Simplifying and condensing equations, especially repetitive ones, would be great.

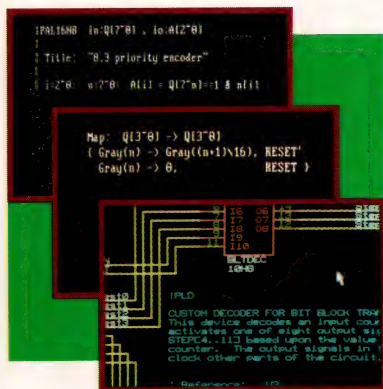
OrCAD/PLD can do all of that.

It would have to work within schematics so documentation would all be in one place.

OrCAD/PLD does that, too.

For output, you need to have a JEDEC file for PLDs and a hex file for PROM burning.

It's easy with OrCAD/PLD.



Accepts multiple inputs, including truth tables, state machines, Boolean equations, indexed equations, schematic entry and numerical mapping.

OR8873-INTL



And logic synthesis? You don't want to buy extra hardware to handle something as complex as that.

OrCAD/PLD offers a whole new way of design expression called **numerical mapping**. Its the most powerful means for designing PLDs on any platform, yet it runs on a standard PC.

The perfect programmable logic design software shouldn't cost a lot.

OrCAD/PLD
comes complete and is
Very Affordable

The price includes one year of technical support, free product updates and access to our 24 hour BBS.

OrCAD 
Systems Corporation

1049 S.W. Baseline Street #500
Hillsboro, OR 97123
(503) 640-9488

If you would like more information about this or any other OrCAD product, contact your local OrCAD representative.

AUSTRALIA
Prometheus
0 3862 3666

AUSTRIA
Dahms Elektronik GmbH
0316 640 300

BELGIUM
INEX
(322) 649-9991

DENMARK/NORWAY
NordCAD
0 817 3299

ENGLAND
ARS Microsystems, Ltd.
(0276) 685005

FINLAND
Elektrotel OY
0754 3122

FRANCE
ALS Design
(01) 46.04.3047

ITALY
BRM Italiana
(011) 7710010

ITALY
MicroData Systems
0187 966 123

JAPAN
Sotec Company, Ltd.
045 (641) 0802

SPAIN
Next-For S.A.
0261 2415

SWEDEN
Technology Partners
08 156815

SWITZERLAND
Logmatic AG
056 83 38 38

WEST GERMANY
COMPWARE GmbH
040 - 818074

Call today for your demo disk

FULL SPE



For the name of your nearest distributor in Europe, call 44-296-625462. Or contact Applied Microsystems Corporation Ltd., Chiltern Court, High Street, Wendover, Aylesbury, Bucks HP22 6EP, United Kingdom. In Japan, call 03-493-0770. Or contact Applied Microsystems Japan Ltd., Nihon Seimei, Nishi-Gotanda Building, 7-24-5 Nishi-Gotanda, Shinagawa-KU, Tokyo T141, Japan.

AMC 240

ED AHEAD.

INTRODUCING THE FIRST 33-60 MHz MICROPROCESSOR EMULATOR FOR THE 68020 AND 68030.

Put your phone in front of you and get ready. You're about to get in touch with the future of high speed microprocessor emulation.

For quite some time Applied Microsystems has been designing a radical new concept in 32-bit development. Now it's ready. The EL 3200.

It's capable of not only matching current speeds, but can efficiently expand to support faster speeds and advanced 32-bit microprocessors of the future.

The news is not just speed, but how the EL 3200 gets up to speed.

It runs at full target clock speed—33 MHz for 68020 and 68030. It fully supports 68030 cache burst and synchronous bus cycles. And, since it sits as a node right on the trunk of your Ethernet network, the EL 3200 can be accessed from any workstation.

The EL 3200 offers your choice of source level or symbolic debugging. Whether you want to work in Assembly or C, we can provide the software tools for your exact needs.

The sophisticated breakpoint system has hundreds of real-time access breakpoints, six real-time execution breakpoints and unlimited software execution breakpoints. As an option, you can have up to 2MB of no wait state overlay memory that runs at full clock speed, so there are no restrictions on memory, software or interrupts. The 16K deep by 139 bit wide trace provides true 32 bit support.

Seeing is believing. For a demonstration or more information, pick up your phone.

Dial full speed ahead and ask for Telemarketing. In WA (206) 882-2000.

Applied Microsystems Corporation, P.O. Box 97002, Redmond, Washington, USA 98073-9702.

1-800-343-3659



Applied Microsystems Corporation



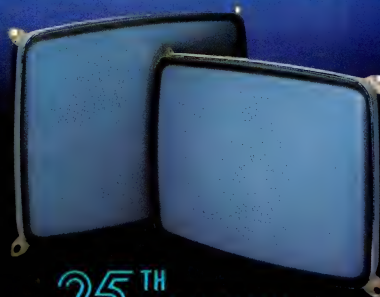
A futuristic approach to CRT technology



...from the industry leader.

While many CRT manufacturers are busy marketing today's technology, Clinton Electronics is forging ahead into the future of the industry. It's this vision that's helped make us the world's number one manufacturer of monochrome CRTs. And in this, our 25th anniversary year, we continue to dedicate all our efforts to give our customers a CRT simply not available anywhere else. At Clinton, "performance has no limits," as exemplified by some of the CRT features we offer:

- 3" to 23" configurations (including 5x9, 7x11, 7x13)
- standard radius and flat profile
- panels including anti-glare
- internal surge limiting
- RFI/EMI shielding
- over 100 phosphors in addition to EIA standards
- special dag coatings
- wide range of mounting systems
- ability to produce 1 to 1,000,000



25TH ANNIVERSARY

We foster innovation of this kind in advanced manufacturing facilities in the U.S. and Far East by developing application and R & D programs unmatched in the industry, by offering special programs for the replacement industry and by nurturing a corporate environment that encourages our talented people to "break through" conventional ideas and seek unique solutions to our customer's problems.

While our **focus** as a company is bringing tomorrow's CRT technology to our customers today, our **philosophy** is firmly anchored in the past: Above all else, deliver **quality, value, and service.** Values that are as important to us now as they were 25 years ago. Just ask our customers. You won't have much trouble finding one.

For more information, call our sales and technical support group today at 815/633-1444. Clinton Electronics, 6701 Clinton Road, Rockford, Illinois 61111



CLINTON
ELECTRONICS
CORPORATION

Finding The Right Embedded Graphics Processor Can Be Harder Than You Think.



Embedded graphics applications can range from PC displays to entertainment systems. So you need a fast graphics system processor that's fully programmable for every high-resolution application.

And you don't need to waste a lot of time trying to find one.

That's why Marshall Industries carries the latest graphics system processor from Texas Instruments. Ready to ship in production quantities.

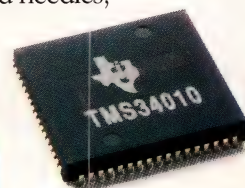
With a 60 million bit-per-second draw rate, seven and one half million instruction-per-second capacity and the ability to draw open and filled geometric shapes, the TMS34010 is available in 40, 50 and 60 MHz speeds. All these features on a single chip make this the most cost-effective graphics processor on the market.

Even better, thanks to Marshall's leadership, you get the full support of a national distributor. Support which includes developer's kits for 34010-based PC systems, software assemblers, hardware emulators, evaluation boards, and extensive documentation. Not to mention the security that comes from dealing with one of TI's largest distributors.

So if finding a reliable source for your embedded graphics solutions has you on pins and needles, call Marshall today.

We won't stick you with anything but a great graphics processor.

Marshall



(*Authorized Locations)

AL Huntsville (205) 881-9235*
AZ Phoenix (602) 496-0290*
 Tucson (602) 790-5687*
CA Irvine (714) 458-5301*
 Los Angeles (818) 407-4100*
 Sacramento (916) 636-9700*
 San Diego (619) 578-9600*
 San Francisco (408) 942-4600*

CO Denver (303) 451-8383*
CT Connecticut (203) 265-3822*
FL Ft. Lauderdale (305) 977-4880*
 Orlando (407) 767-8585*
 Tampa (813) 573-1399*
GA Atlanta (404) 923-5750*
IL Chicago (312) 490-0155*
IN Indianapolis (317) 297-0483*

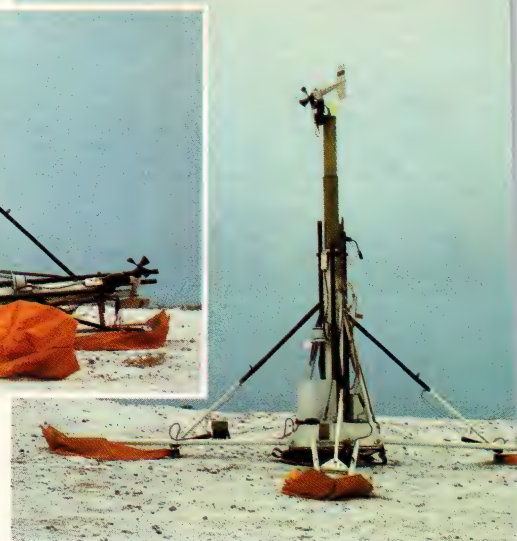
KS Kansas City (913) 492-3121*
 Wichita (316) 264-6333*
MA Boston (508) 658-0810*
MD Maryland (301) 622-1118*
MI Michigan (313) 625-5850*
MN Minneapolis (612) 559-2211*
MO St. Louis (314) 291-4650*
NC Raleigh (919) 878-9882*

NJ N. New Jersey (201) 882-0320*
PA Philadelphia (609) 234-9100*
 Pittsburgh (412) 963-0441*
NY Binghamton (518) 798-1811*
 Long Island (516) 273-2424*
 Rochester (716) 235-7820*
OH Cleveland (216) 248-1788*
 Dayton (513) 898-4480*
 Westerville (614) 891-7580*

OR Portland (503) 644-5050*
TX Dallas (214) 233-5200*
 El Paso (915) 593-0706*
 Houston (713) 895-9200*
 Brownsville (512) 542-4589*
 Austin (512) 837-1991*

San Antonio (512) 734-5100*
UT Salt Lake City (801) 485-1551*
WA Seattle (206) 486-5747*
WI Wisconsin (414) 797-8400*
 In Canada: G.S. Marshall Co.
 Montreal (514) 683-9440*
 Ottawa (613) 564-0166*
 Toronto (416) 458-8046*

**TEXAS
INSTRUMENTS**
 Authorized Distributor



AVSIM HELPS YOU GET PROJECTS ON THEIR FEET

The "creature" shown above doesn't depict a futuristic lunar landing. This is a polar landing of a sophisticated weather monitoring device. Deployed from an aircraft, it unfolds in minutes and begins transmitting vital environmental data.

This Self-Erecting Weather Station, sponsored by the National Science Foundation, was developed by Polar Research Lab. Avocet's AVSIM™ simulator was used on the project.

Stay On Schedule

Using a simulator, you can avoid complications and delays caused by debugging code on unstable target hardware. AVSIM allows you to begin the debug cycle even before the hardware is available.

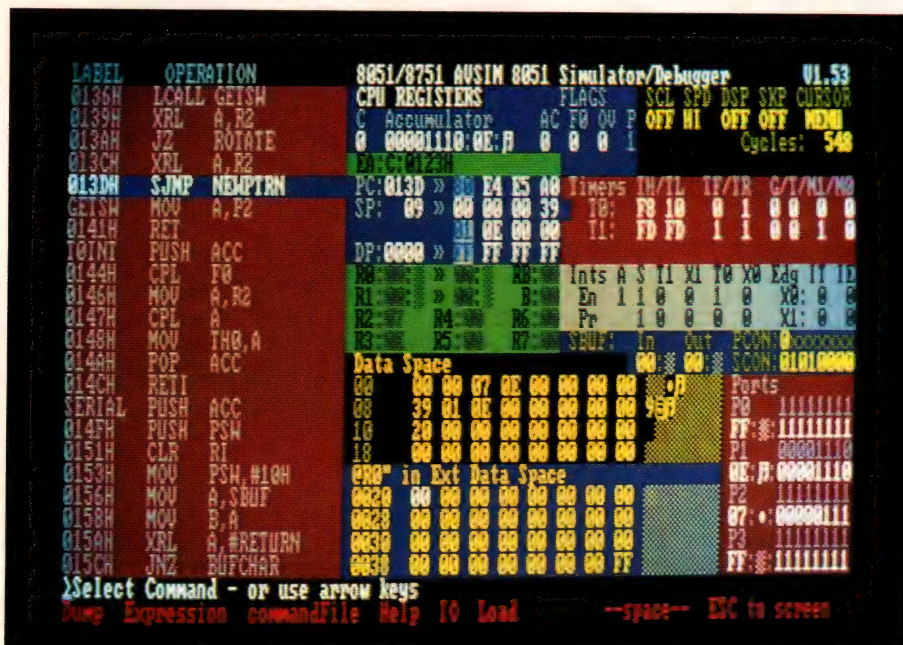
Keep The Project On Your Desk

Work within your familiar MS-DOS environment. With AVSIM you can check the hardware and operating

system interfaces, all on your PC. You don't have to rely on outside staff and equipment. **At only \$379**, AVSIM is a fraction of the cost of additional hardware.



Free Catalog
Call Toll-Free 1-800-448-8500



AVSIM Full-Screen Display

Avocet offers a complete line of embedded-system tools including AVOCET C™ compilers, AVMAC™ macro assemblers, AVPROM™ programmers, and AVSIM™ simulators.

Call Avocet today. Discover how we can help you get your next project on its feet, too.

AVSIM supports:
Intel 8051, 8048, 8085
Motorola 68HC11, 6805, 6800, 6809
Zilog Z80
Hitachi HD64180, 6301
TI TMS32010, TMS32020
Rockwell 6502

©1989 Avocet Systems, Inc. All Rights Reserved.

AVOCET

SYSTEMS, INC.

The Source For Quality Embedded-System Tools

Avocet Systems, Inc., 120 Union St., P.O. Box 490, Rockport, ME 04856 / In Maine, or outside U.S., call (207) 236-9055 / TLX: 467210 Avocet CI / FAX: (207) 236-6713

CIRCLE NO 96

DEPEND ON THE NAME BEHIND THE WORLD'S FIRST STANDARD-SIZE 9-VOLT LITHIUM BATTERY:



Kodak

**Kodak is the name in high-performance batteries
that designers and end users trust.**

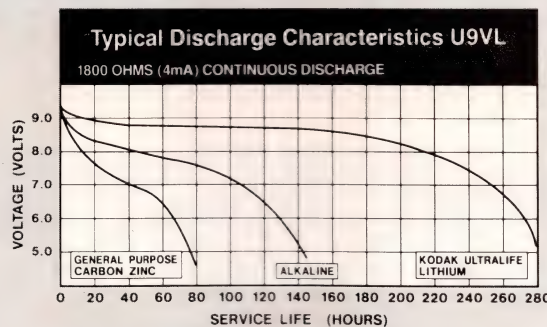
The Kodak Ultralife® lithium power cell is the 9-volt to specify for maximum long-life performance. With *twice* the service life of conventional alkaline 9-volts, it reduces battery changes and equipment down-time. Its innovative design is right for *your* most innovative designs. Flat-folded ribbon electrodes utilize the full interior of the cell.

The 9-volt Kodak Ultralife lithium power cell is your choice for longer life expectancy and consistent discharge characteristics—as well as superior low-

temperature performance. What's more, you can also choose the new 3-volt Kodak Ultralife lithium battery. This 3.6 ampere hour Ultralife

battery delivers high capacity at 3 volts. It makes an excellent backup power source for a wide range of applications, especially in computers and memory systems.

And where alkaline battery performance must be specified, depend on the full line of Kodak Supralife® alkaline batteries...just like millions of your end users do!



**KODAK BATTERIES
DEPEND ON US.**



Eastman Kodak Company, c/o Ultra Technologies Inc.
P.O. Box 267, Newark, NY 14513
1 800 242-2424, 315 332-7230

© Eastman Kodak Company, 1989

The straight ahead solution.



Computers and Communications

For fast answers, call us at:

USA Tel:1-800-632-3531. TWX:910-379-6985.

W. Germany Tel:0211-650302. Telex:8589960.

The Netherlands Tel:040-445-845. Telex:51923.

Sweden Tel:08-753-6020. Telex:13839.

France Tel:1-3946-9617. Telex:699499.

Italy Tel:02-6709108. Telex:315355.

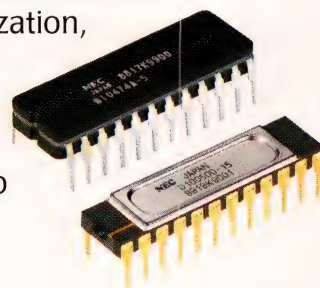


NEC ECL RAMs offer the fastest route to your design goals.

Now there's no question about where to turn for ECL RAMs. NEC offers the high speed and the large capacity you need for mainframes, superminis, workstations, and other speed-driven applications.

For pure speed, try our 1K x 4 chips with 5ns access time. For large capacity, specify our 256K x 1 devices featuring BiCMOS technology. NEC's broad and balanced lineup includes 1K, 4K, 16K and 256K devices. They come in 1-bit or 4-bit organization, with 10K or 100K interface, and offer a variety of speed options.

Wherever your design is going, NEC has the ECL RAM to drive it to success. For fast information, call NEC today.



Device	Interface	Organization	Access time (ns)	Power consumption (W)	Supply voltage (V)	Package		
μPB10422D-7/-10	ECL 10K	256 x 4	7/10	1.2	-5.2±5%	24-pin ceramic DIP		
B10470D-10/-15		4K x 1	10/15			18-pin ceramic DIP		
B10474AD-5/-6		1K x 4	5/6			24-pin ceramic DIP		
B10474D-8/-10/-15			8/10/15			24-pin ceramic DIP		
B10480D-10/-15		16K x 1	10/15			20-pin ceramic DIP		
B10480B-10/-15						20-pin ceramic flat		
B10484D-10/-15		4K x 4	10/15			28-pin ceramic DIP		
B10484B-10/-15						28-pin ceramic flat		
D10500D-15/-18		256K x 1	15/18			24-pin ceramic DIP		
B100422D-7/-10	ECL 100K	256 x 4	7/10	1.0	-4.5±5%	24-pin ceramic DIP		
B100422B-7/-10		4K x 1	10/15			24-pin ceramic flat		
B100470D-10/-15						18-pin ceramic DIP		
B100474AD-5/-6		1K x 4	5/6			24-pin ceramic DIP		
B100474AB-5/-6			8/10/15			24-pin ceramic flat		
B100474D-8/-10/-15						24-pin ceramic DIP		
B100474B-8/-10/-15			4.5/5.0/6.0	2.0		24-pin ceramic flat		
B100474B-45/-50/-60						24-pin ceramic flat		
B100474K-45/-50/-60		16K x 1	10/15	1.0		24-pin LCC		
B100480D-10/-15						28-pin ceramic DIP		
B100480B-10/-15						28-pin ceramic flat		
B100484D-10/-15						28-pin ceramic DIP		
B100484B-10/-15		4K x 4	10/15			28-pin ceramic flat		
B100484K-10/-15						28-pin LCC		
D100500D-15/-18		256K x 1	15/18			24-pin ceramic DIP		

SPACE AVAILABLE

LT 1180/81
+ 4 x 0.1 μ F Caps

Call Linear Technology
800-637-5545

Rugged. Low Power. RS232 Space Saver.

Part Type	Drivers	Receivers	Power Supply Required	Shutdown	Drivers Fault Tolerant to $\pm 25V$	Charge Pump Cap Size Req'd.
LT1030	4	0	$\pm 12V$	YES*	YES	N/A
LT1032	4	0	$\pm 12V$	YES*	YES	N/A
LT1039	3	3	+5V, $\pm 12V$	YES*	YES	N/A
LT1039-16	3	3	+5V, $\pm 12V$	NO	YES	N/A
LT1080	2	2	+5V	YES*	YES	1 μ F
LT1081	2	2	+5V	NO	YES	1 μ F
LT1130	5	5	+5V	NO	YES	1 μ F
LT1131	5	4	+5V	YES*	YES	1 μ F
LT1132	5	3	+5V	NO	YES	1 μ F
LT1133	3	5	+5V	NO	YES	1 μ F
LT1134	4	4	+5V	NO	YES	1 μ F
LT1135	5	3	+5V, $\pm 12V$	NO	YES	N/A
LT1136	4	5	+5V	YES*	YES	1 μ F
LT1137	3	5	+5V	YES*	YES	1 μ F
LT1138	5	3	+5V	YES*	YES	1 μ F
LT1139	4	4	+5V, +12V	YES*	YES	1 μ F
LT1140	5	3	+5V, $\pm 12V$	YES*	YES	N/A
LT1141	3	5	+5V, $\pm 12V$	YES*	YES	N/A
LT1180	2	2	+5V	YES*	YES	0.1μF
LT1181	2	2	+5V	NO	YES	0.1μF

*RS232 3 state outputs.

Linear's 1180/81 product using 0.1 μ F Caps and RS232 family:

- Save board space
- Save Cap costs
- Guarantee no latchup
- Sustain $\pm 25V$ faults without disrupting supplies
- Consume power comparable to CMOS
- 1 μA supply current in shutdown
- Up to 100k baud
- Start at \$2.95 in 100 piece quantities

For a copy of our RS232 hand-book, contact Linear Technology, 1630 McCarthy Blvd., Milpitas, CA 95035. Or Call 800-637-5545.



TOUGH PRODUCTS
FOR TOUGH APPLICATIONS.

Circuit converts pulse height to width

Gordon Anderson
Battelle Northwest, Richland, WA

The output-pulse width from the circuit in Fig 1 is a linear function of the input pulse's height. You can set the circuit's input threshold to discriminate against low-level pulses, while fixed components limit the circuit's maximum output-pulse width.

With a 270-k Ω resistor connected from the -9V supply to the base lead of Q_2 , this circuit can handle input pulses separated by 20 μ sec min; without the resistor, input pulses must occur 80 μ sec apart for correct operation. The turn-off time of zener diode D_2 sets the lower limit for the input-pulse repetition rate.

IC_1 , D_1 , and C_3 detect the peak of the input pulse.

The comparator, IC_2 , triggers at your preset threshold. The RC delay network, R_9 and C_5 , hold off inverter IC_3 's changing state until the completion of peak detection. After IC_{3A} changes state, Q_1 turns on and then turns on Q_2 , a constant-current source.

Constant-current source Q_1 then discharges C_3 , the peak-detecting capacitor. When C_3 has discharged below IC_2 's threshold, IC_2 's output goes low, as do pins 6 and 4 of IC_3 . The output-pulse width is a function of this discharge time, which you can adjust with R_6 . C_6 and R_7 control the maximum output-pulse width, which is 8 μ sec max.

EDN

To Vote For This Design, Circle No 521

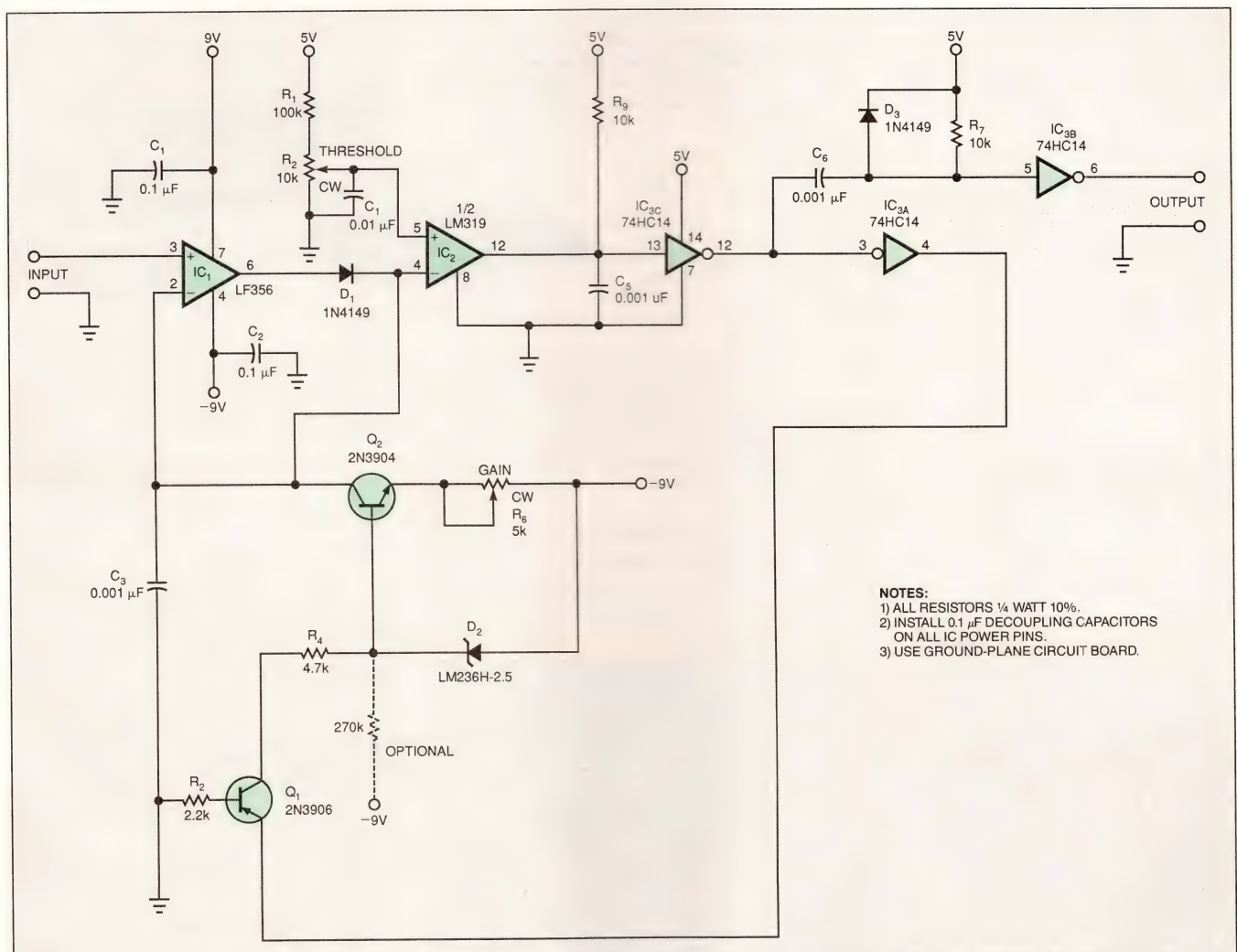


Fig 1—A peak detector and constant-current source combine to form a pulse-height to pulse-width converter.

DIGITAL SCOPES/LOGIC ANALYZERS CAN'T DO THIS!

■ Only ORION delivers next-generation high performance integrated digital scope-logic analyzer with . . .

■ Precisely time-aligned analog and digital traces.

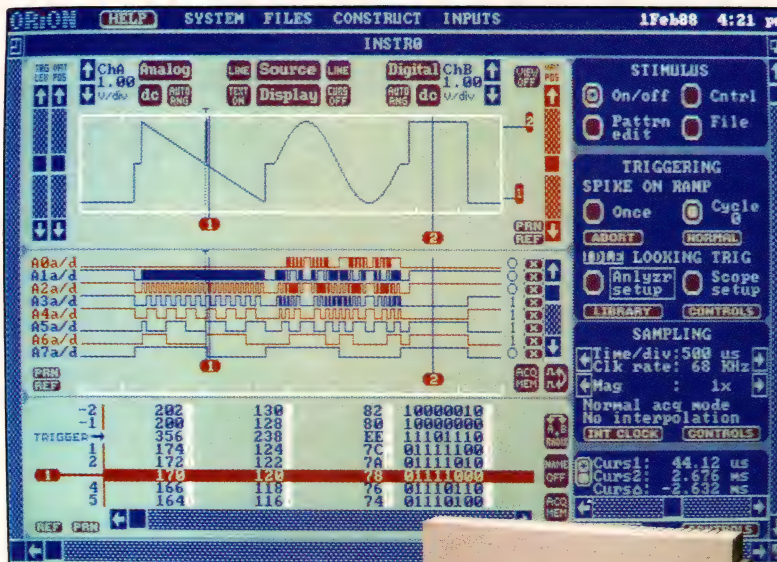
Our 9240 is a whole new class of instrument that vastly simplifies development. It lets you watch time-correlated digital and analog signals from the same circuit—on the same screen at the same time. And with nano-second correlation.

■ SELECT™ triggering for swift sure capture of rare events.

SELECT triggering bridges the gap between scope and analyzer techniques. So you can simultaneously trigger on digital and analog signal abnormalities. With the 9240's deep trace buffer you can scroll back and forth in time, observing fault-causing conditions, and after effects.

■ Customizable instrument configurations.

The 9240's general-purpose hardware allows you to configure and implement numerous application-specific



OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.



instruments on the screen of your AT or PS/2, via simple pull-down menus. Then save the setups for future use. It's like having a benchtop of instruments in one.

■ And with the 9240, you can troubleshoot in fewer steps than ever before—without compromising high

performance specs. Result: you'll pinpoint faults faster and easier, get your designs to market quicker.

For more information, call toll free 800/245-8500. In CA: 415/361-8883. Or write for complete literature.

■ Available for rent from U.S. Instrument Rentals, Inc., 800/824-2873

ORION
INSTRUMENTS

702 Marshall Street
Redwood City, CA 94063
TELEX: 530942 FAX: 415/361-8970

Computer Integrated Instrumentation

*SELECT triggering is a trademark of Orion Instrument, Inc. Hewlett Packard is a trademark of Hewlett Packard Company. Tektronix is a trademark of Tektronix, Inc.

Free
Literature
Available

NO-COMPROMISE 9240 SPECIFICATIONS

DIGITAL OSCILLOSCOPE

Digitizers: Two, 8 bit
Bandwidth: 100 MHz
Single-Shot Digitizing: 34 S/s to 204 MS/s
Repetitive Sampling: 680 MS/s
Scale Factor: 10 mV/div to 10V/div in 1-2-5 sequence
Record Length: 4K (16K optional)

ANALOG STIMULUS

Output: 8mV to 8V peak-to-peak, 8 bit
Cycle Length: 4 to 4K samples (16K optional)
Clocking: 34 S/s to 34 MS/s
Functions: Record, edit and playback

LOGIC ANALYZER

Inputs: 48, timing and state
Asynchronous Clocking: 34 MS/s on 48 inputs; 204 MS/s on 8 inputs
Repetitive Sampling: 680 MS/s on 48 inputs
Synchronous Clocking: 0 to 34 MS/s
Acquisition Memory: 4K samples (16K optional)
Disassembly Options: Over 33 microprocessors

DIGITAL STIMULUS

Outputs: 24, 74F tri-state drivers
Cycle Length: 4 to 4K samples (16K optional)
Timing: 34S/s to 34MS/s
Functions: Record, edit and playback

DRAM tester yields GO/NO-GO information

Dan B Goldish
Raytheon Co, Marlboro, MA

The digital circuit shown in Fig 1 performs a GO/NO-GO test on a 4164 dynamic RAM (DRAM) by continuously alternating 1s and 0s through the ZIF-socketed unit under test, IC₁. This alternating pattern verifies the integrity of the DRAM's 65,536 data locations, as well as the distinctiveness of each of its 16 address lines. The circuit detects internally shorted address lines and stuck data bits.

Sometime after you apply the reset pulse via SW₁, D₁ will flash to indicate that IC₁ passes the test. D₁ is off during the 0s part of the test and on during the 1s. If the DRAM is faulty, the LED will cease to flash and stay illuminated.

Two 8-bit counters, IC₄ and IC₅, drive IC₁'s address lines. The 16R8 controls both counters' enable pins and the $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ lines of IC₁. The 74LS590s have two separate clock inputs: a counter clock, CCK, and

a register clock, RCK. CCK and RCK are driven from opposite edges. The value of the clock generator is not critical; however, it must be between 768 kHz and 11 MHz, so that the circuit drives the DRAM at the proper speed. A 768-kHz oscillator will meet the minimum $\overline{\text{RAS}}$ refresh rate of most 4164 DRAMS, which is 128 rows every 2 msec.

Listing 1 is the Abel source code for the 16R8; Listing 2 presents the reduced Boolean equations that are programmed into IC₂. The terms SELN, RASN, and CASN form a state machine that enables either IC₅ or IC₄ to drive the multiplexed DRAM address lines. The state machine also controls the low logic levels applied to $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$. The terms HALF, RWN, and DOUT form a second state machine, which determines the data value to write or read from the DRAM. The term CCKEN is active for one cycle to allow IC₅ to increment at the next row address. Lastly, the term FIRST is used to bypass the initial DRAM read/verify operation until at least one write cycle has transpired

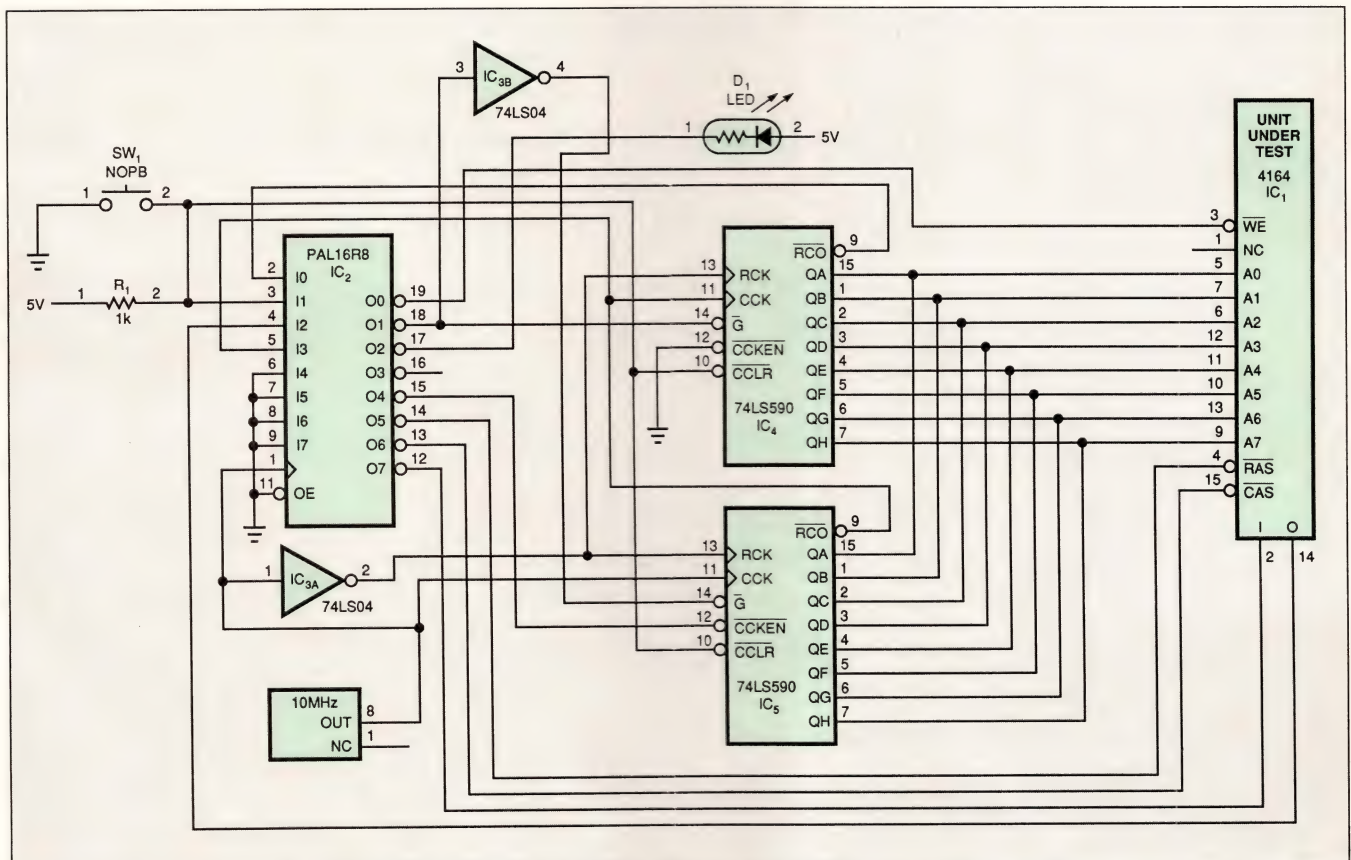


Fig 1—This DRAM test circuit writes 0s and 1s alternately to each data location. A flashing D₁ indicates that the DRAM has passed the GO/NO-GO test.

DESIGN IDEAS

and valid data is written at each DRAM address.

The procedure consists of reading a single DRAM location and then verifying that the data bit is correct. Next, data of opposite polarity is written to the same address location, and its value is read to verify that the data bit did in fact toggle. If this bit location passes, the next address location is tested in an identical manner. When the 8-bit row address rolls over from FF to 00, the 8-bit column address, IC₄, is incremented via the ripple carry out of IC₅. When both the row and

column addresses roll over from FF to 00, the entire DRAM has been tested. The 16R8 then repeats this procedure for the opposite-polarity pattern. Alternate patterns are continuously written and read from the entire DRAM, thus causing D₁ to flash until a DRAM failure.

EDN

To Vote For This Design, Circle No 524

LISTING 1—ABEL SOURCE CODE

```
module dram

    flag '-r3', '-t2'

    title 'DRAM Controller for 4164 Chip Tester'

    U2 device 'P16R8';

    CLK pin 1;

    ck = .C.;

    "Inputs
    RCON1, RESETN, DIN, RCON2
    pin 2,3,4,5;

    "Outputs
    RWN, SELN, HALF, FIRST, CCKEN, RASN, CASN, DOUT
    pin 19,18,17,16,15,14,13,12;

    M2 = [HALF, RWN, DOUT];

    M1 = [SELN, RASN, CASN];

    RCO = !RCON1 & !RCON2;

equations

    M2 := [1,1,1] & !RESETN;

    M1 := [1,1,1] & !RESETN;

    !FIRST := (RCO & (M1==0) & (M2==6)
    # !FIRST) & RESETN;

    !CCKEN := ( (M2==6)
    # (M2==3) ) & (M1==1) & RESETN;

state_diagram M1

    state 7: goto 5;

    state 5: goto 1;
```




value-packed filters from **\$11.45**

dc to 3GHz

- less than 1dB insertion loss over entire passband
- greater than 40dB stopband rejection
- 5 section, 30dB per octave roll-off
- VSWR less than 1.7 (typ)
- over 100 models, immediate delivery
- meets MIL-STD-202
- rugged hermetically sealed package (0.4 x 0.8 x 0.4 in.)
- BNC, Type N, SMA available

finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

LOW PASS	Model	*LP-	10.7	21.4	30	50	70	100	150	200	300	450	550	600	750	850	1000
Min. Pass Band (MHz) DC to			10.7	22	32	48	60	98	140	190	270	400	520	580	700	780	900
Max. 20dB Stop Frequency (MHz)			19	32	47	70	90	147	210	290	410	580	750	840	1000	1100	1340
Prices (ea.): Qty. (1-9) P \$11.45, B \$32.95, N \$35.95, S \$34.95																	

HIGH PASS	Model	*HP-	50	100	150	200	250	300	400	500	600	700	800	900	1000
Pass Band (MHz)			41	90	133	185	225	290	395	500	600	700	780	910	1000
start, max.			200	400	600	800	1200	1200	1600	1600	1600	1800	2000	2100	2200
end, min.			26	55	95	116	150	190	290	365	460	520	570	660	720
Min. 20dB Stop Frequency (MHz)															
Prices (ea.): Qty. (1-9) P \$14.95, B \$36.95, N \$39.95, S \$38.95															

*Prefix P for pins, B for BNC, N for Type N, S for SMA

example: PLP-10.7

C105 REV. E

DESIGN IDEAS

LISTING 1—ABEL SOURCE CODE *(continued)*

```
state 1: goto 0;

state 0: goto 7;

state_diagram M2

state 7: if CASN then 7
        else if !FIRST & !DIN then 0
        else 4;

state 4: if CASN then 4
        else 6;

state 6: if CASN then 6
        else if DIN then 0
        else if !RCO then 7
        else 2;

state 2: if CASN then 2
        else if DIN then 0
        else 1;

state 1: if CASN then 1
        else 3;

state 3: if CASN then 3
        else if !DIN then 0
        else if !RCO then 2
        else 7;

state 0: goto 0;

end dram
```

LISTING 2—REDUCED BOOLEAN EQUATIONS

```
HALF := !( !HALF & RCON2 & RESETN
           # !HALF & RCON1 & RESETN
           # !HALF & RESETN & !RWN
           # !DIN & !HALF & RESETN
           # CASN & !HALF & RESETN
           # !CASN & !DOUT & !RCON1 & !RCON2 & RESETN & RWN
           # !CASN & DIN & !DOUT & RESETN & RWN
           # !CASN & !DIN & DOUT & !FIRST & RESETN & RWN);

RWN := !( !CASN & !DIN & !HALF & RESETN & RWN
          # CASN & !HALF & RESETN & !RWN
          # !CASN & !DOUT & !HALF & RESETN
          # CASN & !DOUT & RESETN & !RWN
          # !CASN & DIN & HALF & RESETN & RWN
          # !CASN & DOUT & HALF & RESETN & RWN);

DOUT := !( !CASN & DOUT & RCON2 & RESETN & RWN
           # !CASN & DOUT & RCON1 & RESETN & RWN
```


DESIGN IDEAS

LISTING 2—REDUCED BOOLEAN EQUATIONS *(continued)*

```
# !CASN & !DIN & DOUT & RESETN & RWN  
# DIN & !DOUT & RESETN  
# !DOUT & HALF & !RCON1 & !RCON2 & RESETN  
# CASN & !DOUT & RESETN  
# !DOUT & RESETN & !RWN  
# !CASN & DOUT & HALF & RESETN & RWN);
```

```
SELN := !(CASN & !RASN & RESETN);
```

```
RASN := !(CASN & !RASN & RESETN # CASN & RESETN & SELN);
```

```
CASN := !(CASN & !RASN & RESETN & !SELN);
```

```
FIRST := !(FIRST & RESETN  
# !CASN & !DOUT & HALF & !RASN & !RCON1 & !RCON2 & RESETN &  
RWN & !SELN);
```

```
CCKEN := !(CASN & DOUT & !HALF & !RASN & RESETN & RWN & !SELN  
# CASN & !DOUT & HALF & !RASN & RESETN & RWN & !SELN);
```

For precisely the control you need.



This is only a part of our line of joysticks, trackballs, mouse controls, control grips and interface circuits. There's just too much to fit into a single picture. So we can probably supply exactly what you need, off the shelf.

On the other hand, it's quite possible that the control you need doesn't exist. Yet. That's why many of our most successful controls are designed to meet "impossible" requirements no standard control could come close to satisfying.

If you need an existing control, or one to be designed, you can depend on our superior performance and exceptional reliability.

For a complete picture of what we can do for you, call or write.



Measurement Systems, Inc.

121 Water Street, Norwalk, CT 06854, U.S.A.
(203) 838-5561

Design Entry Blank

\$100 Cash Award for all entries selected by editors. An additional **\$100 Cash Award** for the winning design of each issue, determined by vote of readers. Additional **\$1500 Cash Award** for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name _____

Title _____ Phone _____

Company _____

Division (if any) _____

Street _____

City _____ State _____ Zip _____

Design Title _____

Home Address _____

Social Security Number _____

(Must accompany all Design Ideas submitted by US authors)

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must not be patented, and must have no patent pending. Design must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed _____

Date _____

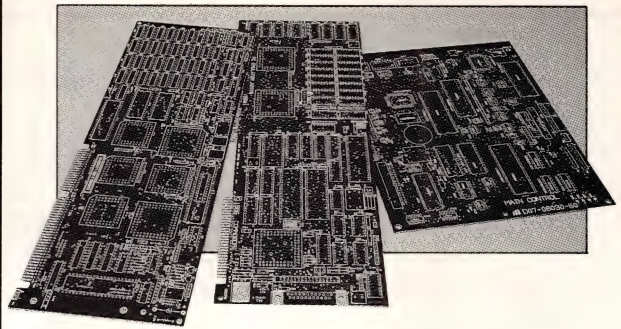
ISSUE WINNER

The winning Design Idea for the April 13, 1989, issue is entitled "386SX interfaces with IBM PC/AT chip set," submitted by Al Weidner of VLSI Technology Inc (Tempe, AZ).

The winning Design Idea for the April 27, 1989, issue is entitled "Single-chip μ P acquires Basic," submitted by G Nagendra Rao of ISRO Satellite Centre (Bangalore, India).

Your vote determines this issue's winner. All designs published win \$100 cash. All issue winners receive an additional \$100 and become eligible for the annual \$1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

GET ON YETI'S TRACK



The mountain man may be out of reach but we are here to serve your demands.

Yeti's printed circuit boards have taken up the challenges of this fast changing world of electronics and OEM equipment since 1984.

Accuracy is guaranteed by our fully automated program controlled production line. Strict quality controls have minimized defection rates. Continuous schooling enables Yeti employees to be up to the latest technical innovations and standards in OEM products. Our mass-production capacities are increasing.

Just snooping for reliable suppliers you should contact us. Yeti is at your disposal.



YETI ELECTRONICS CO., LTD.

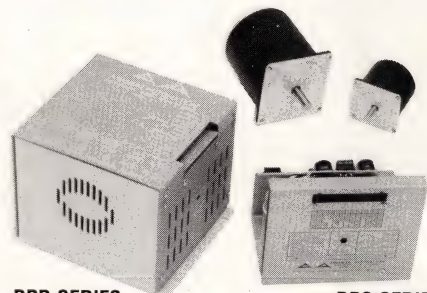
106, KAI LUNG STREET, JIA DONG TSUEN,
BA DER SHIANG, TAOYUAN TAIWAN. R.O.C.
TEL: 886-3-3699121-6 FAX: 886-3-3698362
P.O. BOX: 362, CHUNG-LI, TAIWAN. R.O.C.

CONTACT PEOPLE:

C.K. CHEN-PRESIDENT
JACK HUANG - SUPERVISOR

CIRCLE NO 104

LOW COST - HIGH PERFORMANCE STEP MOTOR DRIVER PACKS



DPD SERIES

DPS SERIES

DPD and DPS are two new, low-cost, high efficiency Driver Pack series. Both series employ bilevel (dual voltage) drive for high-performance operation of 4 phase step motors. They provide significantly improved motor speed torque (power) output and higher start-stop speeds.

The open-frame DPS series includes a .5 to 3 amp driver, power supply and line cord, and offers optional manual and ramping pulse generator. The enclosed DPD series includes one or two drivers (.5 - 3.0 or 1.0 - 6.5 amps), power supply, line cord and optional CL1710 Preset Indexer, (with one driver). *Call or write for complete information.*

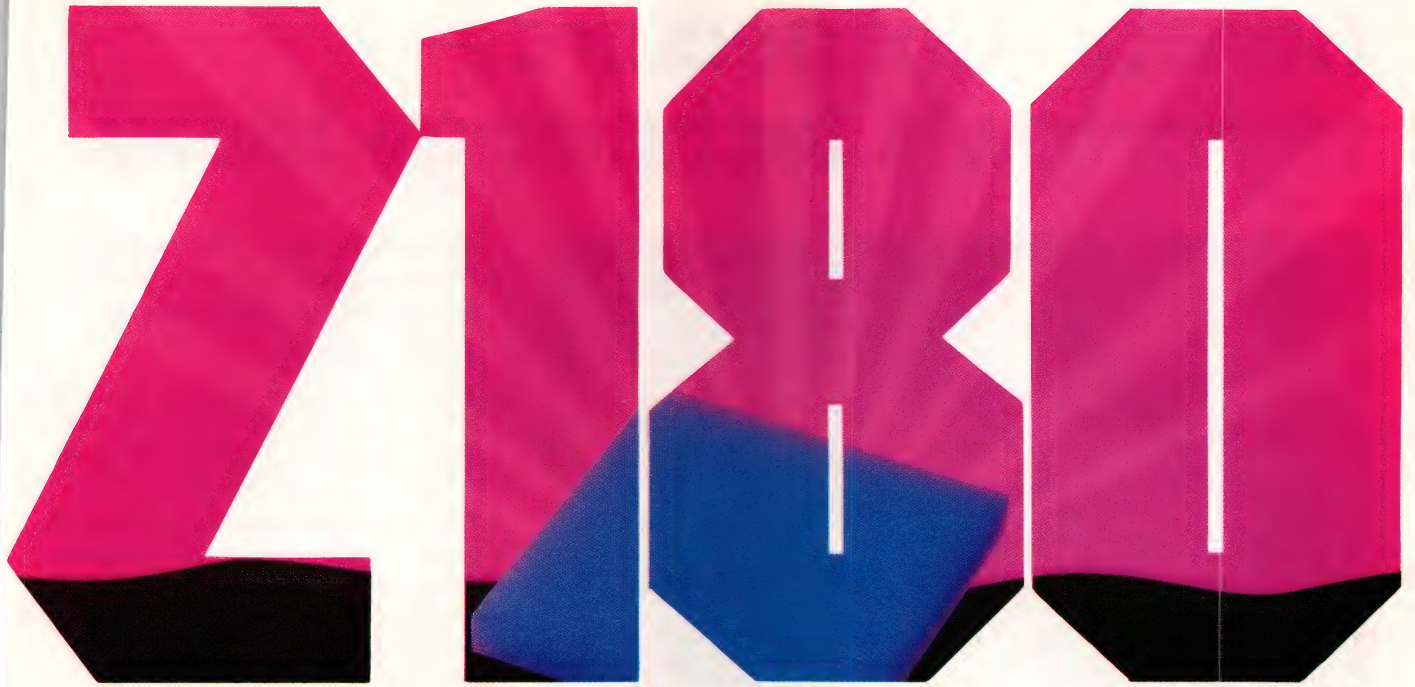


ANAHEIM AUTOMATION

910 E. Orangefair Lane, Anaheim, CA 92801
(714) 992-6990 • FAX (714) 992-0471 • Telex 2978217 MCI

CIRCLE NO 105

Z I L O G



Great code compatibility. Terrific performance. Superintegration.™

Zilog's Z80180™ is the CMOS general purpose controller with the high performance and the on-board peripherals that make it clearly the cost-effective, space-saving choice. Whether you're upgrading a Z80 application or designing a totally new system.

Zilog is Superintegration.

ASICs are the obvious answer to many of today's demands for customized products for specific uses. But it's also clear that, as the demand for higher levels of integration grows, the need for a new approach to ASIC arises. That new approach is Superintegration from Zilog.

Through Superintegration, Zilog has developed a rapidly growing family of Application Specific Standard Products (ASSPs). Simply put, ASSPs are working cores and cells combined and enhanced for specific applications. They are not custom parts. In fact, the ASSPs we develop use the same architecture and the same codes you're already working with. Compared to ASICs, ASSPs mean a lot less risk. And non-recurring engineering (NRE) charges are eliminated. Plus, tight on-silicon coupling enhances performance. And board real estate is significantly reduced. Think what all this can mean to your time-to-market.

And think about this. Nobody has a more complete library of proven, working generic cores, system cells, or I/O bolt-ons than Zilog. Nobody is better qualified to develop—and deliver—Superintegration parts.

Full software compatibility.

You'll be up and running with the Z180 immediately. Because it's 100% object code compatible with Z80/8080.™ You probably already know the code, so you can port right onto the Z180. Not only that, since Zilog originally developed the part jointly with Hitachi, the Z180 is directly compatible with Hitachi's version, the HD64180Z.™

Enhanced performance.

Of course, the Z180's CPU core gives you more power and speed than discrete CPUs. Besides that, there are several new instructions. You also get operating frequencies to 10 MHz. And you have the overall performance advantages of CMOS and Superintegration.™

The important peripherals are on board.

The Z180's high integration results in impressive savings in costs and real estate. The MMU gives you one Mbyte of addressing space. You have 2 DMA channels, 2 UART channels, and 2 16-bit programmable counter-timers. Plus wait-state generators, an interrupt controller, a clock oscillator/generator, and a clocked serial I/O port. All integrated on the Z180 chip.

If this isn't enough to convince you to take a look at what the Z180 can do for your design project, here's a little more to consider. The full complement of development support tools are readily available from industry leaders. And the Z180 comes to you off-the-shelf, backed by Zilog's proven quality and reliability. Find out more about the Z180 or any of Zilog's growing family of Superintegration products. Contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.

Right product. Right price. Right away. ZILOG

ZILOG SALES OFFICES: CA (408) 370-8120, (714) 838-7800, (818) 707-2160, CO (303) 494-2905, FL (813) 585-2533, GA (404) 923-8500, IL (312) 517-8080, MA (617) 273-4222, MN (612) 831-7611, NJ (201) 288-3737, OH (216) 447-1480, PA (215) 653-0230, TX (214) 987-9987, CANADA Toronto (416) 673-0634, ENGLAND Maidenhead (44) (628) 39200, W. GERMANY Munich (49) (89) 612-6046, JAPAN Tokyo (81) (3) 587-0528, HONG KONG Kowloon (852) (3) 723-8979, TAIWAN (886) (2) 741-3125, SINGAPORE 65-235 7155. **DISTRIBUTORS:** U.S. Anthem Electric, Bell Indus., Hall-Mark Elec., JAN Devices, Inc., Lionex Corp., Schweber Elec., Western Microtech. CANADA Future Elec., SEMAD. LATIN AMERICA Argentina-Yel. (1) 46-2211, Brazil-Digibyte (011) 241-3611, Mexico-Semiconductores Profesionales (5) 536-1312.

Bendix® Connectors — tomorrow's technology today.



Programmable – Removable filter or transient protection for maximum flexibility in circuit design.

The Bendix® transient protection system is the weight, space and cost saving way to protect sensitive circuitry from interference or destruction by energy transients.

To meet these threats the Bendix® system can package filters, diodes or metal oxide varistors (MOV) individually or in combination within a connector that is intermateable and intermountable with MIL-SPEC connectors. This same protection is now available with **programmable – removable** EMI/EMP contacts.

Programmability with rear insertable, rear removable contacts enhances user flexibility, allowing unique mixes of filters, ground contacts, feed-thrus and power contacts.

System maintenance is simplified using Bendix® front repairable connectors. The need to remove flex print or printed circuit boards for repair purposes is eliminated, as is the need to enter a sealed box.

Programmable or repairable EMI connectors are available with single capacitors or Pi filter arrangements in the MF, VHF, and UHF frequencies. EMP repairable protection is available for sensitive circuits ranging in voltage from 5V to 200V, and with unipolar or bipolar characteristics. Both pin and socket contacts are available in sizes 16, 20 and 22.

For more information on the Bendix® programmable – removable transient protection system

**Call (607) 563-5301
or (607) 563-5309**

Bendix Connector Operations
40-60 Delaware Avenue
Sidney, New York 13838-1395

Amphenol

an *LPL* company

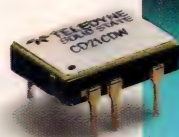
SOLID STATE RELAY

Now a cheap off-the-shelf SSR that puts you in control. It lets you control the cost and the system's function in military applications.

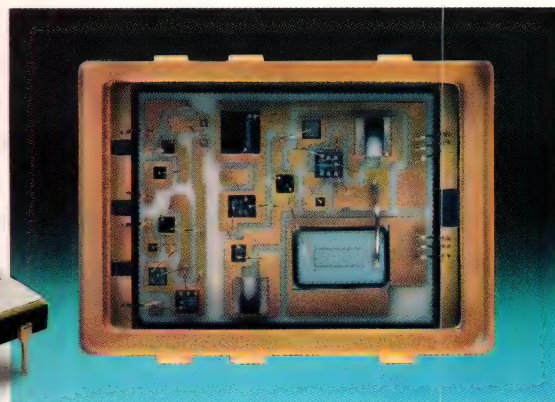
#2
IN A SERIES

Here's what you get.

- Short Circuit Protection
- Status Indication
- Current Overload Protection
- Optical Isolation
- TTL & CMOS Compatible Control
- Built to meet the requirements of MIL-R-28750.
- Cost Effective



ACTUAL SIZE
CERAMIC PACKAGE



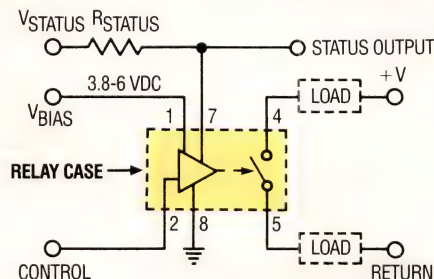
PART # CD21CDW

Review the electrical characteristics and call us for immediate application assistance.*

ELECTRICAL CHARACTERISTICS (-55°C to +105°C unless otherwise noted)				
	Min	Max	Units	
Bias Voltage (V_{BIAS})	3.8	6.0	V_{DC}	See Note 1
Bias Current (I_{BIAS})		15.0	mA	$V_{BIAS} = 5V_{DC}$
Control Voltage (V_{IN})	0	18.0	V_{DC}	
Control Current (I_{IN})		250	μA	$V_{IN} = 5V_{DC}$
Turn-Off Voltage ($V_{IN(OFF)}$)	3.2		V_{DC}	
Turn-On Voltage ($V_{IN(ON)}$)		0.3	V_{DC}	
Continuous Load Current		1.2	A	-55°C to +25°C
$I_{LOAD @ 60VDC}$		0.7	A	+85°C
Output Trip Current (I_{TRIP})	2.4 (Typ.)		A	+25°C, 100ms
On-Resistance (R_{ON})		0.65	Ohms	
Turn-On Time (T_{ON})		1.5	ms	
Turn-Off Time (T_{OFF})		0.25	ms	
Status Voltage (V_{STATUS})	1	18	V_{DC}	$V_{SAT} \leq 0.3V_{DC}$
Status Current (I_{STATUS})		2	mA	See Note 2

Notes: 1. Series resistor is required for bias voltages above 6V_{DC}. $R_S = (V_{BIAS} - 6V_{DC})/15 \text{ mA}$
 2. A pull up resistor is required for the status output. $R_{STATUS} = (V_{STATUS} - 0.3)/I_{STATUS}$
 3. Output will drive loads connected to either terminal (sink or source).
 4. Status circuit is a built-in test feature checking the input circuitry of the relay. Status output is low (on) when the input is on.

All power FET relays may drive loads connected to either positive or negative referenced power supply lines (source or sink modes).



TELEDYNE SOLID STATE
A Division of Teledyne Relays

*For immediate application assistance call 1-800-284-7007.

Teledyne Solid State, 12525 Daphne Avenue, Hawthorne, California 90250.

Announcing a military display of power in 16.8 million brilliant colors. And olive drab.

BROOKTREE DRAFTS THE INDUSTRY-LEADING VIDEODACS™ AND RAMDACS™ FOR MIL-STD-883C, CLASS B DUTY. NOW HIGH RESOLUTION COLOR GRAPHICS ARE AT YOUR COMMAND.

Brooktree now offers high resolution graphics devices compliant to MIL-STD-883C. So if you're eager to add color graphic displays of data to avionics, C³, EW, radar, sonar, instrumentation or other systems, we've got off-the-shelf solutions ready for you.

When it comes to innovative integrated circuits that bridge the gap between a system's microprocessor and CRT, Brooktree has set the standard. Again and again. Our RAMDACs and VIDEODACs have revolutionized the work-station and high-end graphics marketplace. Now these same devices are ready for military applications, providing up to 256 simultaneous colors from palettes up to 16.8 million colors in size.

THE FIRST WAVE

We're introducing our first five mil-spec devices simultaneously.

Our two monolithic +5V CMOS 8-bit VIDEODACs, the **Bt101/883** and **Bt102/883** lead the way. Use the triple

MIL-SPEC DEVICES			
DEVICE	SPEED	DESCRIPTION	PACKAGE
•Bt101SC883	30MHz	Triple VIDEODAC	40 pin Sidebrazed DIP
•Bt102TC883	50MHz	Single VIDEODAC	24 pin Sidebrazed DIP
•Bt438SC883	125MHz	Clock Generator	20 pin Sidebrazed DIP
•Bt453SC883	40MHz	Triple RAMDAC	40 pin Sidebrazed DIP
•Bt458SG883	110MHz	Triple RAMDAC	84 pin PGA

8-bit, 30 MHz **Bt101/883** as a single chip answer. For higher performance, use three single 8-bit, 50 MHz **Bt102/883s**.

Our RAMDACs have revolutionized high-end graphics systems design. By integrating 256x24 color palettes into our triple 8-bit monolithic +5V CMOS **Bt453** and **Bt458**, we created an industry-standard architecture, available today to military designers. And our **Bt438/883** provides the necessary clock generator for these high speed RAMDACs.



NEW RECRUITS COMING

Add color graphics to your mil-spec system with Brooktree.

Count on Brooktree to bring wave after wave of mil compliant devices to drive your color displays, with higher levels of integration and higher performance. For more information on the complete Brooktree Military 883C Program, including complete screening and processing criteria, call Brooktree at 1-800-VIDEO IC. Brooktree Corporation, 9950 Barnes Canyon Rd, San Diego, CA 92121 TLX 383 596

VIDEODAC and RAMDAC are trademarks of Brooktree Corporation.

CIRCLE NO 109

Brooktree
BT ALL THAT YOU CAN BE!



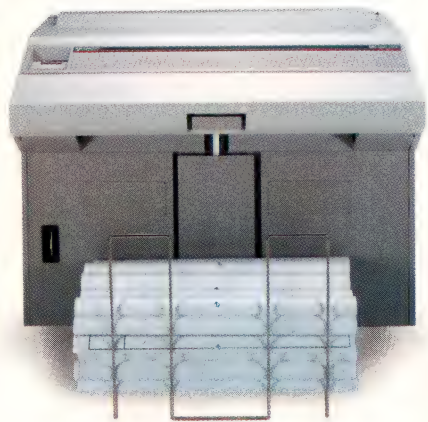
The best part of this story is you can change the plot.

Presenting the Versatec 8836. The first wide format plain paper plotter.

Our story begins with the widest 400 ppi laser output you've ever seen. Cleaner and sharper than pen or electrostatic plots. And 6 to 20 times faster than pen plotters. With the kind of gray scales, solid fills and tone patterns you can't get from pens.

But our most exciting plot development is plain to see.

It's the paper. Plain paper you can write on to make corrections or initial renderings. And since the paper on the 8836 is so wide, you can print and make notes on your whole design—not just parts of it. Saving you valuable time.



Plain paper also lets you operate under a broader range of temperature and humidity conditions. So unlike many other plotters, the 8836 serves you anywhere it's needed in your company.

And it connects with virtually any system, interface or format. HPGL, 906/907, 7436, RS-232, Centronics, VPI, PCs, workstations and mainframes. As you can see, this story has no surprises.

But it does have a thrilling wind up. It's how the 8836 plotter winds up the plot. After automatically cutting it, it's taped and deposited in a convenient bin. Making the Versatec 8836 the first plotter to deliver totally unattended operation.

To hear the unabridged version of this story call (800) 538-6477. In California: (800) 341-6060.

And see how changing the plot can help your business live happily ever after.

VERSATEC

We deliver performance.

© 1989, Versatec Inc.
2710 Walsh Ave., Santa Clara, CA 95051
Versatec is a trademark of Versatec Inc.

CIRCLE NO 110

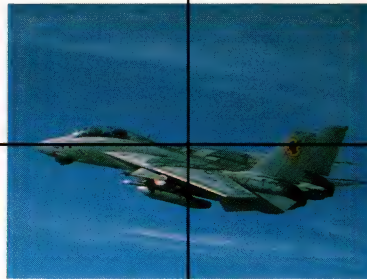


Locked-on Performance...



"Meridian's Quickport gave us an Ada compiler in less than six months. Now we can concentrate on high performance Ada computation, not on compiler details."

Charles Wetherell,
Ardent Computer



"Meridian's technology will allow us to grow from training to full scaled development into the '90s. Meridian designed a license for us to train over 300 people and will allow us to graduate into a developer's license."

Dr. Jerry Pixton,
Unisys Defense Systems



"Meridian's flexibility in licensing allowed the university to accommodate all of its Ada students, providing them with individual compilers for use in their dorm rooms and in our laboratories."

Richard Pattis,
University of Washington

Share in the Wealth of Ada.

You can join these satisfied Meridian users.

Of course, there are plenty of good suppliers. And many platforms that run Ada. But for the best price/performance ratio in the industry, you need Meridian.

After all, we were the first to bring Ada to the native IBM PC™ and Macintosh™ environments. Then we developed support for Sun workstations, DECstation™ 3100 workstations, and almost every IBM clone.

If it's training for your corporation or university you're after,



we can customize a site-license program to meet your special needs. Or you can become a technology licensee. We port the fastest in the industry and we can lead you into the Ada market in less than six months. In short, whatever your need, Meridian can meet it.

So call us today. And get the AdaVantage.™

For more information, contact: Meridian Software Systems, Inc.
23141 Verdugo Dr., Suite 105, Laguna Hills, CA 92653
(800) 221-2522 or (714) 380-9800.

CIRCLE NO 111

MERIDIAN

S O F T W A R E S Y S T E M S I N C

AdaVantage is a trademark of Meridian Software Systems, Inc. Macintosh is a trademark of Apple Computers, Inc.
IBM PC is a trademark of IBM. DECstation is a trademark of Digital Equipment. ©1989

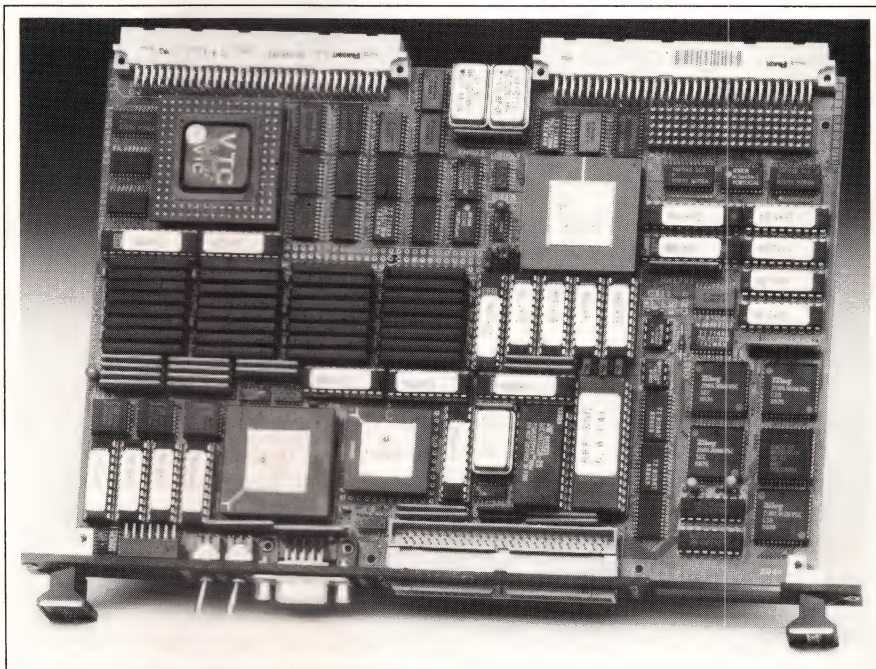
NEW PRODUCTS

COMPUTERS & PERIPHERALS

CPU BOARD

- Has 20-MHz 68030 μ P for VMEbus
- Burst-mode access reads cache lines in 280 nsec

The Eurocom-6, a CPU board for the VMEbus, uses a 20-MHz 68030 μ P and has a 68882 coprocessor. A burst-mode access reads complete 4 \times 32-bit cache lines in 280 nsec from its local 8M-byte dynamic RAM. Gate arrays implement VMEbus interface features such as slot one function, master/slave access, interrupt handler and requester, bus arbiter and requester, block mode, and DMA transfer mode. All these features are software programmable. The board also has 256-byte-wide registers that can serve as semaphores to trigger local interrupt requests in multiprocessor applications. Other features include a SCSI interface with a 64k-byte FIFO buffer, four RS-232C ports, a 16-bit parallel



port, and six programmable 16-bit timers. Its 2k-byte battery-backed static RAM stores data while the power is off. 20-MHz version, \$4500.

American Eltec Inc., 479 S Mar-
engo Ave, Pasadena, CA 91101.
Phone (818) 449-1558. FAX 818-
578-0054.

Circle No 360



MONITORS

- Come in 15-in. portrait or 19-in. landscape display formats
- 15-in. model displays 3300 \times 2560 pixels with 300-dpi density

The Exact-8000M series comprises two high-resolution, monochrome monitors that come in either 15-in. portrait or 19-in. landscape display

formats. Both units display 3300 \times 2560 pixels and have horizontal and vertical pixel densities of 300 and 250 dpi, respectively. Other features include a 750-MHz video bandwidth, a horizontal scan rate of more than 210 kHz, and a noninterlaced refresh rate of 60 Hz. Both units accept analog video inputs, and they have dynamic pin-cushion correction and multipoint dynamic focusing. The yoke handles 15A of deflection current when operating at 210 kHz. Instead of a CRT tube, the units use a high-precision electron gun mated with a low-cost glass bulb from Hughes Display Products. Including power supplies, 15-in. model, \$2890; 19-in. model, \$3690 (OEM qty).

Flanders Research Inc., 88
Bartley Square C-6, Flanders, NJ
07836. Phone (201) 584-0116.

Circle No 361



80386 COMPUTERS

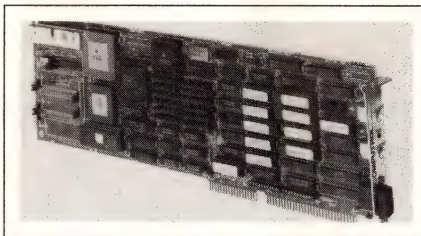
- Run at 33 MHz and have 64k bytes of cache memory
- One 32-bit, six 16-bit, and one 8-bit expansion slot

The DeskPro 386/33 consists of three models of 33-MHz 80386-based computers. Standard configurations include a 33-MHz 82385 cache-memory controller with 64k bytes of 25-nsec cache memory; a

16-bit integrated video-graphics controller; 2M bytes of 32-bit-wide RAM (expandable to 16M bytes); a parallel port; a serial port; a mouse interface; a 300W power supply; one 32-bit, six 16-bit, and one 8-bit expansion slot; a disk-caching utility; a security lock; and an enhanced 101-key keyboard. Options include a 33-MHz 80387 or Weitek 3167 coprocessor; a 360k-byte or a 1.2M-byte 5¼-in. floppy-disk drive; a 1.44M-byte 3½-in. disk drive; an 84M- to 650M-byte hard-disk drive; a 15-MHz ESDI controller; a 2400-baud modem; a 40M-byte tape drive; and video graphics monitors. Model 84 with 84M-byte drive, \$10,499; Model 320 with 320M-byte drive, \$14,999; Model 650 with 650M-byte drive, \$17,999.

Compaq Computer Corp., 20555 FM 149, Box 692000, Houston, TX. 77269. Phone (713) 370-0670.

Circle No 362



NETWORK CONTROLLER

- Provides MAP interface for IBM PCs and compatibles
- Transfers data at 75,000 bytes/sec between two application levels

The LP-25 is a Manufacturing Automation Protocol (MAP) network-controller board for IBM PC, PC/XT, PC/AT, and compatible computers. The board and its associated MAP 3.0 software transfer data as fast as 75,000 bytes/sec over a MAP network from one application level to another. Running layers 2 through 7 of the IEEE 802.4 protocol, the board communicates directly to an off-board compatible

modem. Using a 12-MHz 68020 μ P and an independent DMA controller for data transfers, the LP-25 also features 1M byte of RAM, a 68824 token-bus controller, 512k bytes of EPROM, and a 68091 multifunction peripheral controller. A variety of options support broadband, carrier-band, and fiber-optic networks. Current software packages run with MS-DOS. \$2300.

Computrol Inc., 239 Ethan Allen Hwy, Ridgefield, CT 06877. Phone (203) 431-2000. FAX 203-431-2090.

Circle No 363

LAN ACCELERATORS

- Speed forwarding rates of bridges, gateways, and routers
- Have 4096 \times 48-bit content-addressable memory array

These three IBM PC/AT-compatible boards are hardware accelerators for LAN products. The boards

SYSTEMS READY TRANSIT CASES

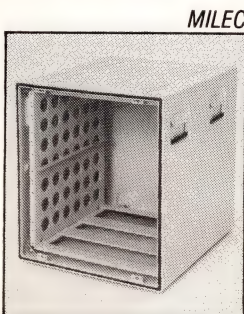
MIL-SPEC RELIABILITY

EDAK provides fully ruggedized transit cases designed to protect against water, sand, dust, shock, vibration and the hazards of extreme conditions.

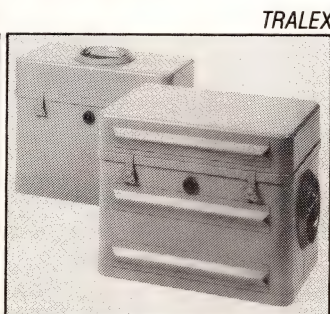
MILEC—Built to military specs for ultimate protection in transport or operation under severe environmental stress.

TRALEX—Transit and operational cases to safeguard valuable electrical or electronic equipment.

A-CASE—Stackable off-the-shelf transit cases in many sizes.



MILEC



TRALEX

Features:

- Shock isolated chassis
- EMI shielding
- Special storage
- Positive stacking
- Cooling provisions
- Custom designs



A-CASE



Swiss engineering +
American craftsmanship =
world class performance

EDAK INC

285 North Drive Suite H Melbourne Florida 32934

(407) 242-2953
FAX (407) 242-3430

Your ultimate bridge from 1553B to all the computing power you need:

Radstone Mil-Spec VME and Multibus boards.

Now you can connect your 1553 application to high performance, NDI Mil-Spec VMEbus or Multibus computing power. Radstone's 1553 boards are all you need. You can put together a complete Mil-Spec computer system with our supporting processor, memory, I/O and communications boards, ATR chassis and software...for VME or Multibus.

Radstone 1553...full compliance, maximum functionality

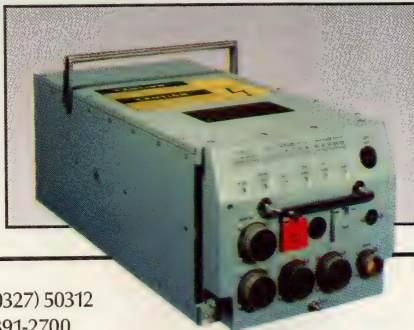
Radstone's Mil-Spec 1553B boards serve as the ideal platform to high performance computing. They offer the optimum combination of full compliance with MIL-STD-1553B and either VMEbus or Multibus specs. And they're loaded with the functionality you want for your system, including:

- MIL-STD-1553B dual redundant multiplexed data bus on a single board
- Bus Controller, Remote Terminal and Passive Bus Monitor
- Intelligent interface supported by dual-ported memory

- On-board microcontroller that reduces system overhead
- ATR Chassis and Ada support

Connecting You to Radstone Mil-Spec Products

With Radstone Mil-Spec 1553 boards, you can pass mission critical information to control tactical vehicles such as ships, tanks and aircraft, as well as ground based support facilities. In fact, Radstone 1553 boards are your direct access from the 1553 communications bus to the world's broadest range of full Mil-Spec NDI computer products. Combined with Radstone's other full Mil-Spec computer products, we supply the military exactly what it needs, and we've done so for over 20 years.



Connecting you to Radstone Ruggedized and Commercial Products

In support of tactical applications requiring less than mission critical service, our ruggedized and commercial grade 1553 boards link you to the VMEbus and Multibus on a double Eurocard form factor. Because Radstone's philosophy is to deliver exactly what you need, our supporting processor, memory and I/O boards are also offered in ruggedized and commercial grades.

Hi-Rel Support for Hi-Rel Products

All Radstone 1553 and other Mil-Spec boards are produced in a facility that meets DOD, DEF-STAN and NATO quality standards and are backed by the industry's most knowledgeable and responsive technical support team. Only Radstone brings together the 1553 bus and the power of the VMEbus or Multibus. Call or write for details.

UK Water Lane, Towcester, Northants, NN12 7JN, (0327) 50312
USA 20 Craig Road, Montvale, NJ 07645-1737, (201) 391-2700
France 'Miniparc', 6 avenue des Andes, 91940 Les Ulis, (1) 64.46.04.03
Germany Bahnhofstraße 38, D-6090 Rüsselsheim (0 61 42) 6 80 04



RADSTONE
TECHNOLOGY

speed up the forwarding rates of bridges, gateways, and routers. You use the SMC4k-TR accelerator for token-ring LANs and the SMK4k-FD accelerator for Fiber-Distributed Data Interface (FDDI) LANs; the SM4k-GP is a LAN prototyping board. Each board features a content-addressable mem-

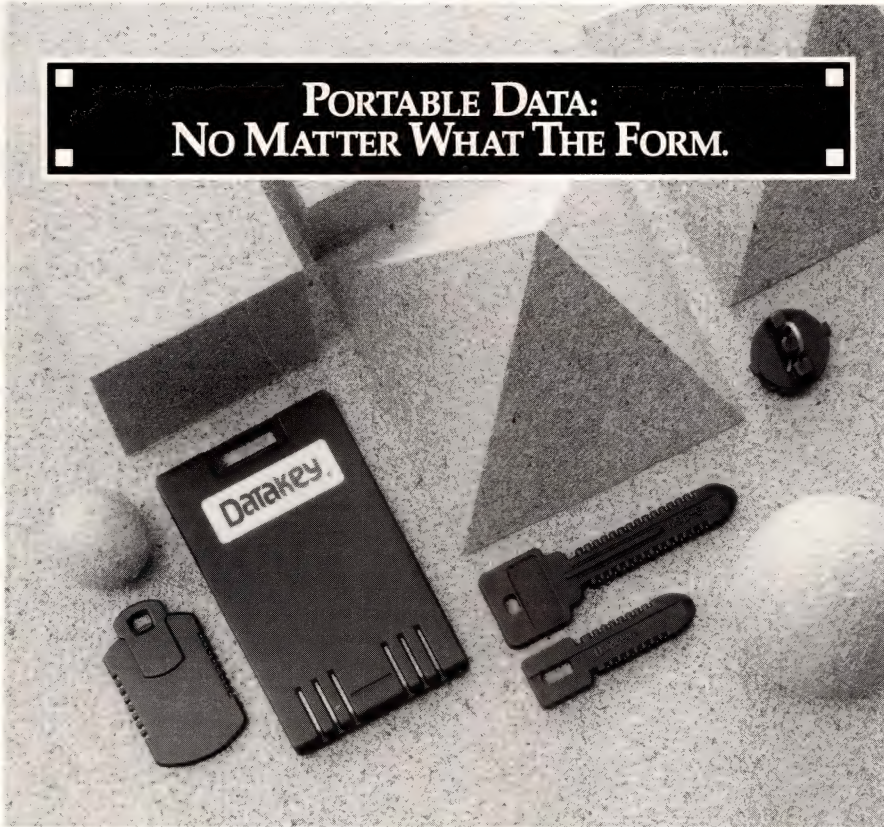
ory (CAM) array, as large as 4096×48 -bits, which stores node addresses. The accelerators can search all of the words in the CAM and compare them with a 48-bit LAN destination address within 100 nsec. The dual-bus configuration consists of a LAN-adapter bus and an IBM PC/AT bus. Menu-

driven C software that simplifies the user interface is also available. Board with a 1024×48 -bit CAM array, \$875; board with 4096×48 -bit CAM array, \$1625. Delivery, six weeks ARO.

Summit Microsystems Corp., 949 Hillsboro Ave, Sunnyvale, CA 94087. Phone (408) 730-4996.

Circle No 364

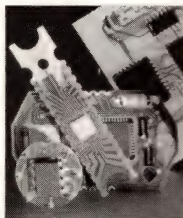
PORTABLE DATA: NO MATTER WHAT THE FORM.



For your next portable data application, choose the firm that has the most experience and technical expertise: Datakey, Inc.

Over the past decade, we've designed and built more types of rugged, portable, easy-to-use data carriers than any other firm... keys, tags, plug-type devices, memory cards, and other "smart" tokens.

Since pioneering the key-shaped data carrier in 1981, our specialized expertise in packaging EPROM and microprocessors has led to many advances in transportable data. Today, our standard products include several devices with nonvolatile, read/write memory to meet your application needs:



Serial Memory Keys: Serial I/O devices with 1-kbit, 2-kbit, or 4-kbit storage capacity.

Parallel Memory Keys: For applications requiring high speed or direct microprocessor interface, with either 16-kbit or 64-kbit capacity.

We've also designed and built custom portable data carriers, for a whole range of applications... including the access device for the U.S. government's secure phone system... the largest single communications-security application to date.

Call us toll-free today to discuss your requirement, whether it involves a single custom prototype or thousands of units from our full line of standard products.

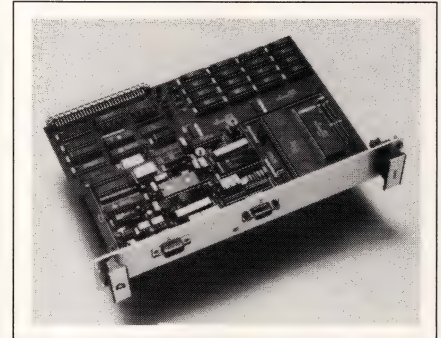
Datakey®

1-800-328-8828

(Ext. 217 for Standard Products,
Ext. 229 for Custom Applications)

Datakey, Inc. • 407 West Traveler's Trail Burnsville, MN 55337 U.S.A. • Phone (612) 890-6850 • Fax (612) 890-2726

CIRCLE NO 114



GRAPHICS BOARD

- Logic for overlaying NTSC video inputs for VMEbus
- Uses 63484 ACRTC chip and 512k bytes of onboard memory

The DGC2 graphics board for VMEbus systems uses Hitachi's 63484 advanced CRT controller (ACRTC), which implements all the graphics control functions. The board contains as much as 512k bytes of graphics memory. The board's logic circuitry allows the ACRTC to be synchronized with an external video signal. The ACRTC output is synchronous with the input image when a decoder oscillator generates the ACRTC pixel-clock frequency. Synchronization essentially stabilizes the image. The board accepts nonmodulated NTSC inputs in the decoder and RS-170 video inputs. Supporting commands for drawing rectangles, polylines, polygons, circles, and ellipses, the board also displays split screens, zooms with 16 to 1 range, and scrolls vertically and horizontally. \$2240 (101).

Dynatem Inc., 19 Thomas, Irvine, CA 92718. Phone (714) 855-3235. TWX 910-595-2603.

Circle No 365



This is ICI Imagedata's Digital Paper.

A simple enough name, but then it's less of a mouthful than "revolutionary flexible optical data storage material".

Our substantial investment resulted from a market trend toward the processing of images, particularly color images.

It's flexible, indelible and can be produced for a remarkably low cost.

Since then, ICI Imagedata has been working with hardware manufacturers to bring Digital Paper into the workplace.

In fact this year the first Creo optical drives to use tape made from Digital Paper

WHY DID WE SPEND MILLIONS OF DOLLARS ON A PIECE OF PAPER?

What was needed was a way to store and print them electronically, so ICI began looking for the appropriate technologies.

Obviously, any potential solution would have to take account of the large storage capacity needed, as well as performance and expense. Nothing short of a revolution was required.

That revolution resulted in Digital Paper.

One 12 inch reel of tape made from this new optical material can store, on-line if you want, a whole terabyte of information. That's 10^{12} bytes, the equivalent of around one billion sheets of typed A4 paper – sufficient to store 55,000 full color images.

will be delivered.

ICI's research budget of \$2.5 million per day has also created a separate technology that can print those stored color images.

Known as D2T2, it can produce a photograph-like color print or transparency direct from an electronic source.

With developments like Digital Paper to talk about, ICI Imagedata are keen to begin discussions with progressively minded drive manufacturers.

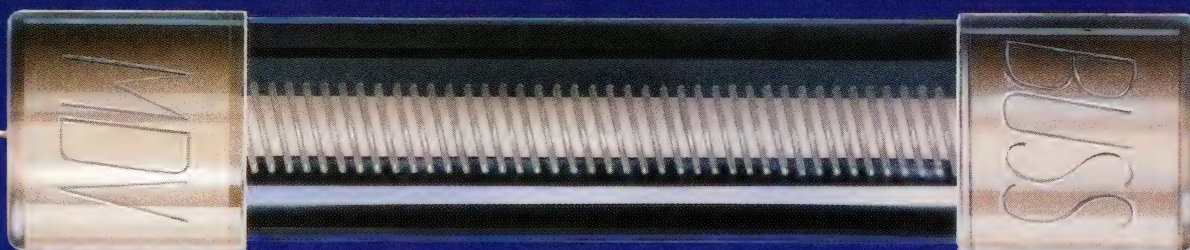
For a complete briefing, call David Owen at 302-886 8484, or write to us at ICI Imagedata, Concord Pike, Wilmington, DE 19897.

© ICI Americas Inc. 1989
ICI Imagedata is a part of ICI Films, a business unit of ICI Americas Inc.



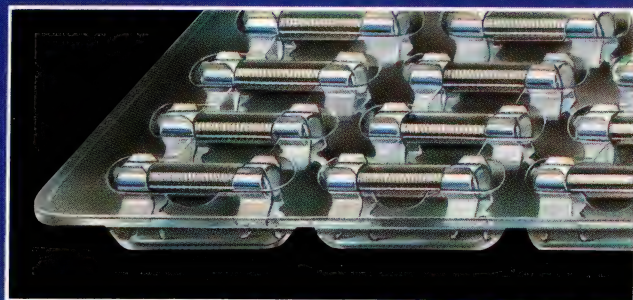
Imagedata

NON BREAKTHROUGH BY BUSSMANN



NEW GLASS TUBE FUSE KEEPS WASHING FLUID OUT.

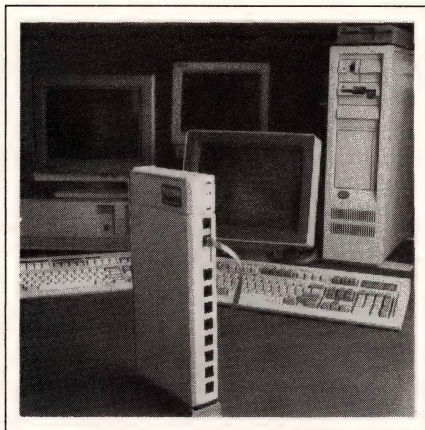
Washing of printed circuit boards carrying glass tube fuses has long posed an open-ended problem: every "nth" fuse will fill with washing fluid. Compromising performance and creating field problems. ■ An expensive solution has been to substitute dummies for the fuses before washing and replace them with fuses afterwards. Now Bussmann offers glass tube fuses which are sealed against moisture—avoiding field problems and eliminating extra manufacturing steps. It's the same glass fuse you're using, the same footprint but with one important difference. ■ For test samples contact Bussmann Division, Cooper Industries, P.O. Box 14460, St. Louis, MO 63178, (314) 394-2877.



New BUSSMANN sealed glass tube fuses are available pre-inserted into PCB clips and assembled into trays to maintain registration during shipment. Now you can order, inventory and install one part number instead of three. And insure reliable fuse performance in your product while reducing manufacturing cost.



BUSSMANN



CLUSTER CONTROLLER

- Connects two or more hosts in a StarLAN
- Multiple RJ-45 ports that connect to a host 800 ft away

The MH800 cluster controller connects two or more host computers in a StarLAN configuration. You connect each host on the network to the controller by installing a single StarLAN board in the computer. Each computer can have different operating systems. Twisted-pair telephone-grade wire connects the board to the host as far as 800 ft from the unit. The unit has eight RJ-45 phone jacks for simple snap-on connections. The ports operate simultaneously at 19.2k baud and are programmable from 50 to 38.4k baud. You can expand the LAN to as many as 100 nodes using multiple-cluster-controller connections. The unit has two 16-bit μ Ps, which offload many of the I/O tasks from the host CPU. 8-port unit for IBM PC/AT hosts, \$1495.

Star Gate Technologies Inc., 29300 Aurora Rd, Bentley Park S, Solon, OH 44139. Phone (800) 782-4283. FAX 216-349-2056.

Circle No 366

FRAME GRABBER

- 512 \times 512 \times 8-bit resolution
- Accepts RS-170, NTSC, or CCIR monochrome video inputs

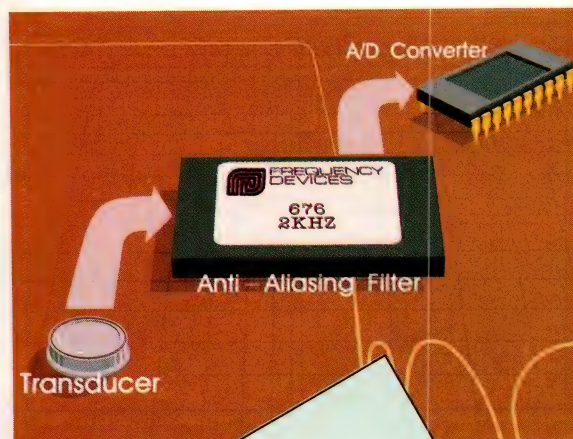
The MV2 frame-grabber board for the IBM PC, PC/XT, PC/AT, and compatible computers accepts RS-

170, NTSC, or CCIR monochrome video inputs from interlaced, noninterlaced, or line-scan cameras. A single input channel acquires video data at the real-time speed of 30 frames/sec and digitizes it to 512 \times 512 \times 8-bit frame resolution. Because the image data gets mapped into the I/O space, the host

can access the data through I/O read/writes. The board can display an image through its output section or through an IBM VGA-compatible adapter board in the host. The board's output section consists of three 256 \times 8-bit display look-up tables that simultaneously display 256 colors from a palette of 16 million.

Anti-Alias Filters to Match A/D Converter Needs

650/670 Series Fixed Frequency, Cauer Elliptic Filters for 8, 10, 12, and 14 Bit A/D's



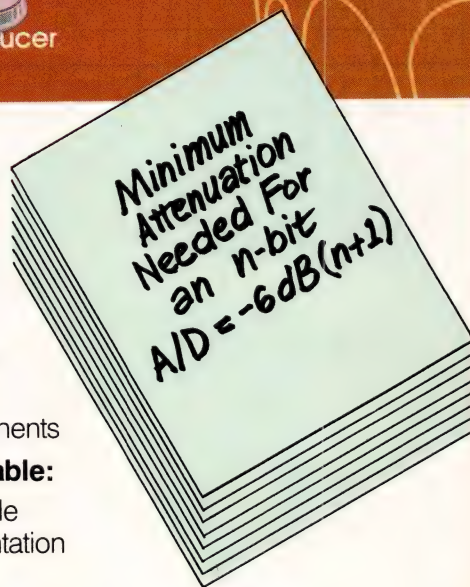
Features:

- Extremely steep roll-off
- Up to 90 dB attenuation level
- Close unit to unit gain and phase matching
- Plug in, ready to use, fully finished, filter module
- 5th (650) and 7th (670) order active lowpass filters
- Requires no external components

Other Filter Products available:

- Linear phase • Programmable
- Fixed Frequency • Instrumentation
- Custom Designs

For more information, please call us at **508-374-0761.**



FREQUENCY DEVICES™

Three 15×8-bit overlay look-up tables provide IBM EGA/VGA text and graphics overlays. A complete software library comes with the board. Board and software, \$1200.

MetraByte Corp., 440 Myles Standish Blvd, Taunton, MA 02780. Phone (508) 880-3000. FAX 508-880-0179. TLX 503989.

Circle No 367

CARD READERS

- *Low-profile design for smart cards*
- *Contact arrangements meet ISO and CP8 standards*

The Smartcard Reader line of low-profile card readers for smart cards features zero-insertion force, thus minimizing wear. Contact arrangements for the reader meet ISO and CP8 standards. Dual heads and hybrids with both microchip and magnetic-strip readers are available.

Card-handling systems include push-push, push-pull, pushmatic with automatic card ejection, push-lift, and push-press with a spring-release card return. The series provides a variety of connectors for flat-cable or flexible-circuit strips. All models pass a 50,000-cycle test. \$10 to \$35. Delivery, eight to 12 weeks ARO.

Amphenol Industrial Technology Div., Box 4185, Hamden, CT 06514. Phone (203) 287-7300.

Circle No 368

A/D BOARDS

- *10- or 12-bit accuracy digitizing at 20M samples/sec*
- *Daughter board ADC module mounts on 6U VMEbus card*

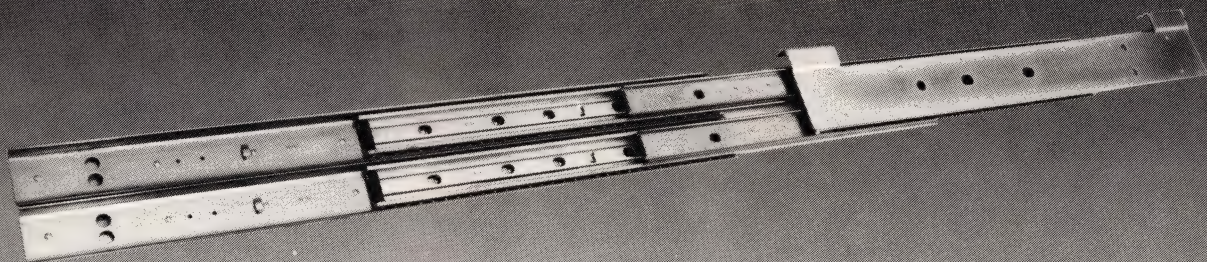
The ADC10/20M and the ADC12/20M are A/D converters for the VMEbus that can digitize analog data at rates as high as 20M sam-

ples/sec with 10- or 12-bit accuracy, respectively. A daughter board ADC module mounts on the reverse side of a 6U VMEbus board. The board also contains a 12-bit DAC that converts data at 20M samples/sec and acts as a system monitor to drive $\pm 1.0V$ into 50 Ω . Besides the analog input, the board can accept 16-bit digital words at 20M words/sec through a front-panel DB25 connector. The board's digital output appears on the P2 connector. Both cards accept analog-input voltages in the range of $\pm 1.0V$, and they have 50 Ω input terminations. The boards operate from $\pm 15V$, 5V, and $-5.2V$, and dissipate 20W. 10-bit card, \$4995; 12-bit card, \$9499.

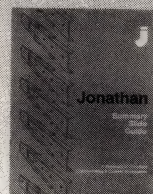
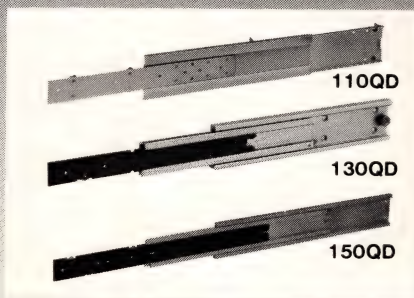
DSP Systems Corp., 1081 N Shepard St, Unit-H, Anaheim, CA 92806. Phone (714) 630-1330. FAX 714-630-6320.

Circle No 369

"Buck Passer"



Manufacturers of Automatic Teller Machines have found they need a rugged, reliable slide mechanism for their cash dispenser — one that can stand up to the rigors of daily use and abuse. Jonathan has responded with a specially designed slide of exceptional strength, reliability and longevity. This steel, 4-section, ball-bearing tiered slide has a 140 lb. capacity, over its 34-inch extension. Built with a 4:1 safety factor, it has been tested to over 50,000 cycles, with outstops impacted and a 10 lb. side load applied. ■ If you have a problem involving chassis slides or other similar slide devices, talk to us at Jonathan — our Application Engineering Group probably has a reliable answer . . . at an economical price.

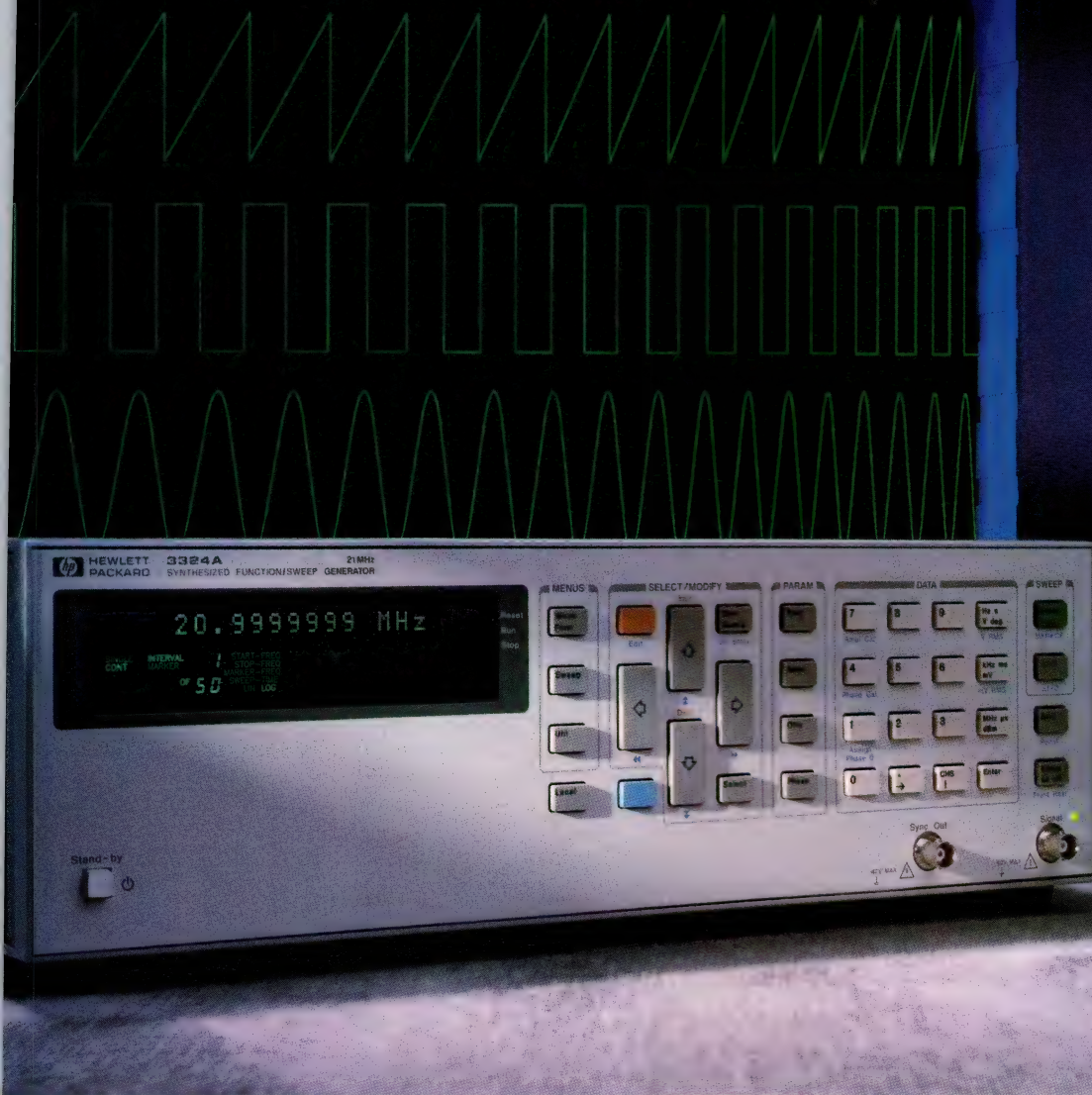


Jonathan's extensive lines of chassis slides are industry standards in industrial and aerospace applications — with load ratings to 800 lbs.

Jonathan Manufacturing Corporation • 1101 So. Acacia Ave., Fullerton, CA 92634 • (714) 526-4651 • FAX: 714-773-5582

CIRCLE NO 118

Synthesizer performance... at a price to generate some waves.



©1989 Hewlett-Packard Co. TMBID904/F

The new HP 3324A Synthesized Function/ Sweep Generator.

The low price of this new generator is bound to generate some waves. It's much less than you'd expect to pay for a function generator that has 5 ppm frequency accuracy, 9-digit frequency resolution and multi-interval sweep capabilities too.

Put it to work in testing filters and amplifiers where you need synthesizer accuracy, stability and signal purity. Tap its high linearity and multi-interval sweep features for A/D converter testing and for simulating rotating signals. Phase-lock two instruments together to calibrate phase meters and discriminators.

And there's more. Such as the

high-stability frequency-reference option, and a high-voltage output option for making really big waves. To find out how low the price really is, call your local sales office today. Ask for our detail-packed brochure and application information.



NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

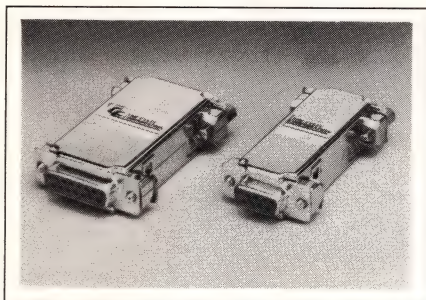
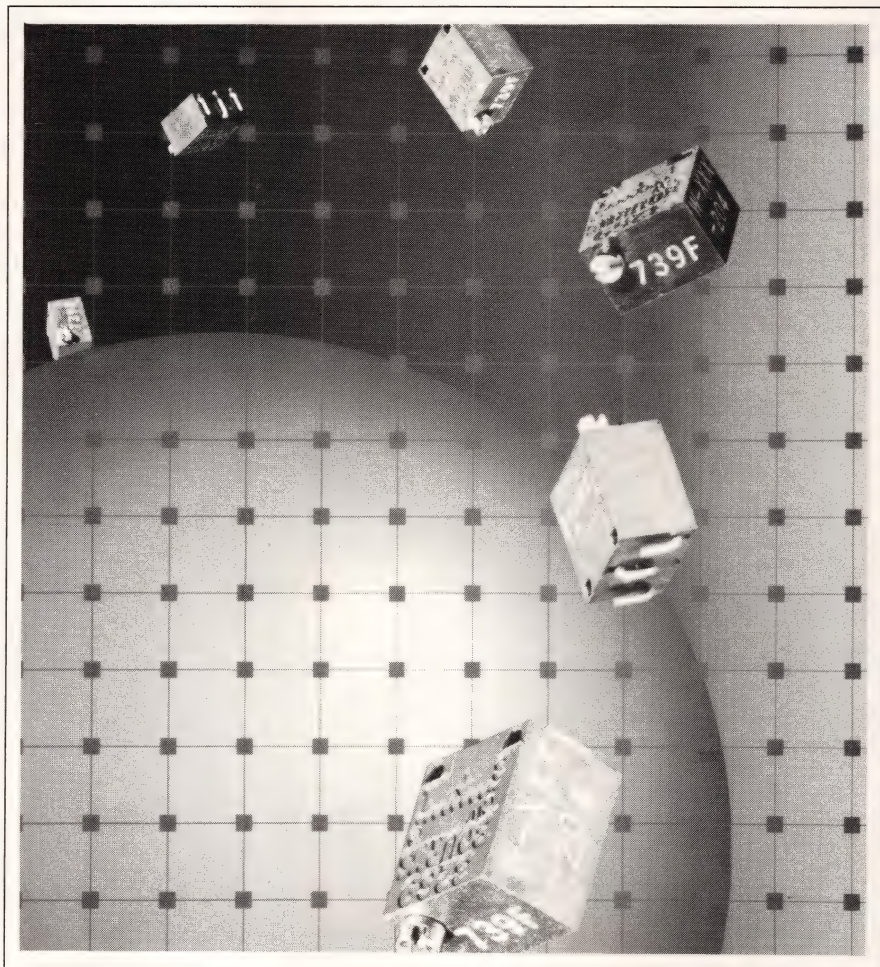
TRIMMER

- Compatible with surface-mount soldering processes
- Sealed to accommodate aqueous cleaning techniques

Measuring 0.25 in. square, the Model 3269 multiturn trimmer is approved per DESC drawing 88040 and meets MIL-R-22097 specifications for nonwirewound variable resistors. The unit is compatible with all popular surface-mount soldering processes. In addition, it is sealed to meet the requirements of high-pressure aqueous cleaning techniques. Standard resistance values range from 10 Ω to 1 M Ω . Resistance tolerance is 10%, and resistance contact variation is 3%. The trimmer also features a 250-mW power rating, a 100-ppm/ $^{\circ}$ C temperature coefficient, and a -65 to +150 $^{\circ}$ C operating range. It's available in top- and side-adjust styles. From \$1.98 (1000). Delivery, 10 weeks ARO.

Bourns Inc., 1200 Columbia Ave., Riverside, CA 92507. Phone (714) 781-5500. TLX 676423.

Circle No 351



PROTECTORS

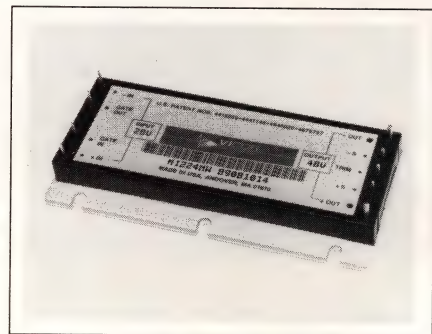
- Provide added security for vulnerable data lines
- Feature a 5-nsec clamp time

The SIP-15M/F(LAN) and SIP-09M/F(LAN) secondary interface protectors enhance the integrity of data transmissions and provide added protection for vulnerable equipment on long cable runs. The

-15M/F(LAN) is fully compatible with Ethernet standards; the -09M/F(LAN) accommodates any 9-pin RS-422 or RS-232C interface. Both models are bidirectional and feature a clamping response time of 5 nsec for each protected pin. The -15M/F(LAN) unit protects a total of eight wires—six signal and two power. The -09M/F(LAN) device protects all nine wires, clamping at either 7 or 27V, depending on the application. Each device provides grounding through its respective connector shell. \$50 each.

The Cylux Corp., 2637 Townsgate Rd, Suite 200, Westlake Village, CA 91361. Phone (805) 379-3155. FAX 805-378-4551.

Circle No 352

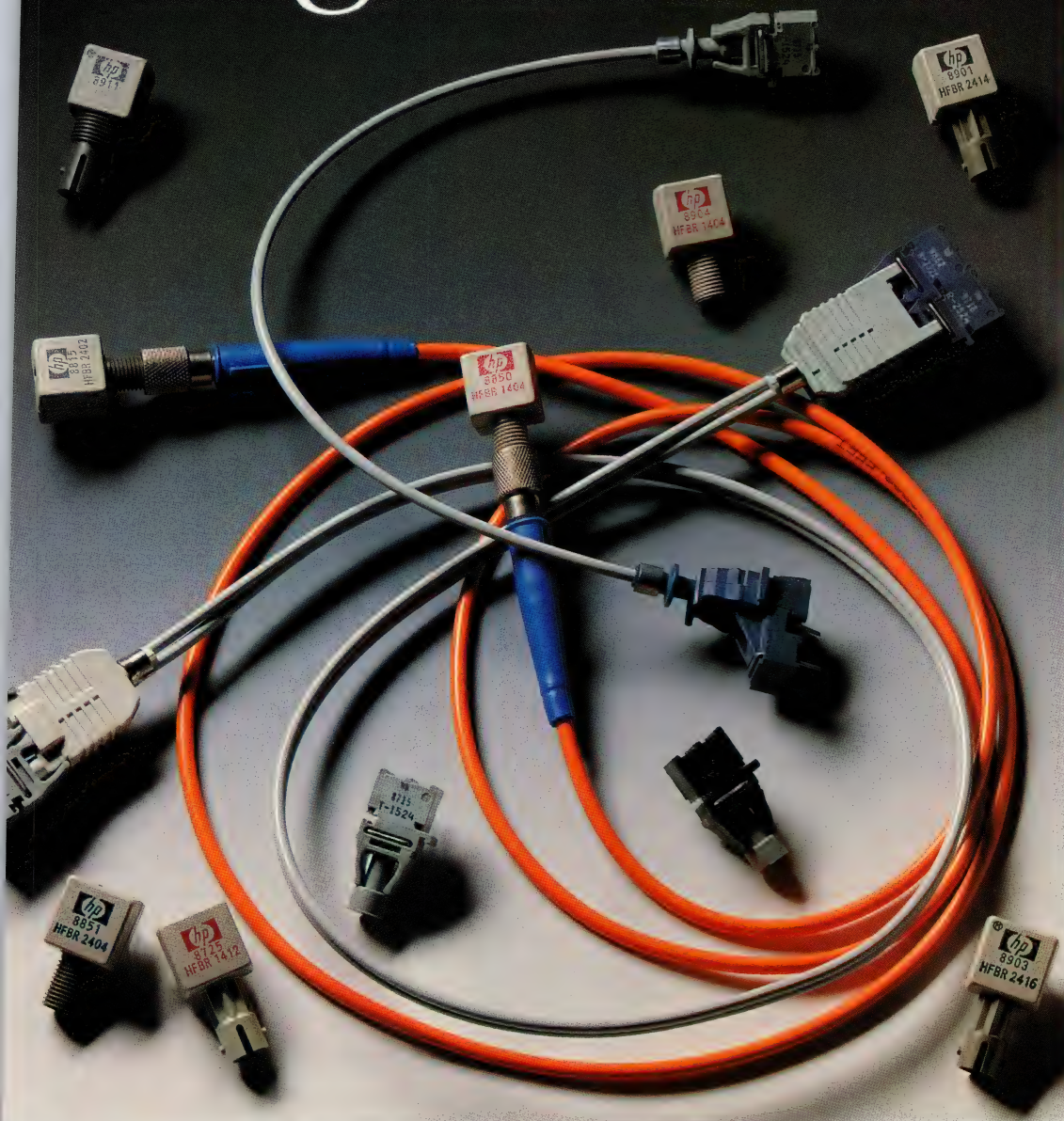


DC/DC CONVERTERS

- Offer 100W output
- Operate to 85 $^{\circ}$ C

The MI Series military dc/dc converters are available in 28V (MI-220) and 270V (MI-260) versions. The MI-220 units accept 18 to 50V inputs, and the MI-260 models have a 125 to 400V input range. The con-

High in fiber.



At HP, we've got all the fiber-optic components you need. And all at a price that's good for your health.

Our HBFR-0400 family of 820 nm fiber-optic transmitters and receivers provides cost-effective fiber-optic links of up to 4Km. With no assembly time.

The 125 MHz analog receiver is designed for high-speed data links, providing data rates of up to 150MBd. And its wide dynamic range is compatible with the IEEE 802.3 FORIL standard.

The transmitters are specified with four types of fiber and are

designed for high-speed transmission, such as with TAXIchip links.

Both the transmitter and receiver are compatible with popular ST and SMA connectors.

HP's HFBR-0501 Versatile Link family includes a complete line of 665 nm fiber-optic transmitters, receivers, connectors and cable. All designed to provide you with a low-cost solution.

Our wide range of plastic cable and connector options includes simplex, duplex, latching and non-latching. Which offers you a cost-effective

alternative to copper wire while it provides design flexibility.

Best of all, they're from HP. So you're always assured of HP's commitment to excellence in service, support and reliability.

For a free information package describing our full line of fiber-optic solutions, call **1-800-752-0900, ext. 219R**. It's the best way to get your fiber.

There is a better way.



**HEWLETT
PACKARD**

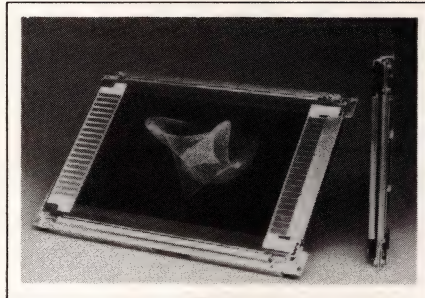
CG 08905

verters offer standard outputs of 5, 12, 15, 28, and 48V at 50, 75, and 100W. The units have a power density of 23W/in.³, an 85% efficiency, 3% p-p noise, and a 500,000-hour min life. The converters are rated for full-load operation over -55 to +85°C. All units can be trimmed over a 0 to 110% output range.

Overvoltage protection, overtemperature protection, current limiting, remote sense, and inhibit are standard. \$540 to \$680. Delivery, stock to 10 weeks ARO.

Vicor Corp., 23 Frontage Rd, Andover, MA 01810. Phone (508) 470-2900. FAX 508-475-6715.

Circle No 353



PLASMA DISPLAY

- Consumes only 35W
- Has a 120° min viewing angle

FPPF8050HFUG-A ac memory plasma display carries a Class-B rating—it meets approvals of all UL, FCC, and CSA standards. The 640 × 400-dot display consumes 35W at full 100% illumination and has a 50,000-hour MTBF. The orange-on-black display features a 120° min viewing angle, a 20:1 contrast ratio, and a character brightness of 44 fL. Complete with driver circuitry mounted directly to the back of the panel, the unit measures just 1.063 in. thick. The viewing area measures 8.3 × 5.2 in., and the entire panel weighs 2 lbs. \$665 (1000).

Fujitsu Component of America, 3330 Scott Blvd, Santa Clara, CA 95054. Phone (408) 562-1000. FAX 408-727-0355.

Circle No 354

POWER SUPPLY

- Operates in on-line or standby modes
- Available in 3-, 5-, and 10-kVA models

The Topaz Powermaker Mini uninterruptible power supply (UPS) is available with input/output voltages of 120, 208, 220, 230, or 240V ac. Users can select any combination of these values on-site, so one UPS will satisfy applications anywhere in the world. Available in 3-, 5-, and 10-kVA models, the unit can operate on-line or in a standby mode. In the on-line mode, the Mini completely isolates systems from the ac line to provide maximum protection. In standby, the unit has a



EMI/EMP HEADACHES?



MIL-C-24308
Medium and high density arrangements

- Physical stress isolated solderless design
- Monolithic planar filter construction
- 8 weeks delivery on standard configurations

THE COMPLETE HEADACHE FREE SOLUTION BY...AMPHENOL

25 years of technical leadership in filter connections.

Amphenol Canada Corp.
an *LPL* company

20 Melford Drive, Scarborough, Ontario, Canada M1B 2X6

TELEPHONE
(416) 291-4401

FAX
(416) 292-0647

STD BUS HAS



THE SOFTWARE

The low cost bus structure of choice for industrial applications, the STD Bus is not only rugged, reliable and simple to design with, it also has the best software support of the industrial busses.

Development Tools

A wide variety of development tools are available for dedicated PROM-based applications, as well as operating system implementations.

- PC to STD communication packages allowing the use of PCs for STD system development.
- Linkers and Loaders
- Prom prep packages

Device Drivers

STD manufacturers support their I/O products with device driver software that can be used with and without operating systems and can be called from many popular languages.

Operating Systems

STD Bus manufacturers offer operating systems for a variety of applications.

- Familiar Disk Operating Systems - PC DOS, MS DOS, and more.
- Real-Time Operating Systems -VRTX, AMX, MTOS, and more.
- Network Operating Systems -ViaNet, NetWare, and more.

For more information on the systems and software offered by the members of the STD Manufacturer's Group, call 312/255-3003 or circle the reader response number.

STD
The Cost Effective
Industrial Computer

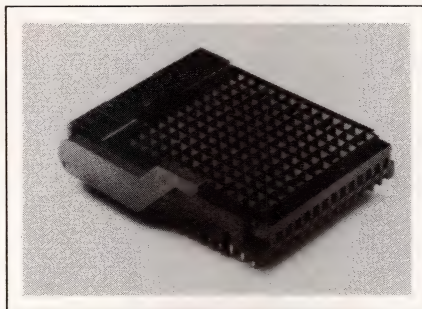
CIRCLE NO 122

COMPONENTS & POWER SUPPLIES

4-msec max transfer time. The use of insulated-gate bipolar-transistor (IGBT) PWM technology provides a 300% overload capability. The supply provides a 100-dB common-mode noise attenuation and a 48-dB normal-mode attenuation. It uses sealed lead-acid batteries, which provide 10 minutes of backup time. The batteries are located on two slide-out trays for easy from-the-front installation, servicing, and replacement. \$6150 to \$14,900.

Square D Co., Power Protection Systems, 9192 Topaz Way, San Diego, CA 92123. Phone (619) 279-0111.

Circle No 355



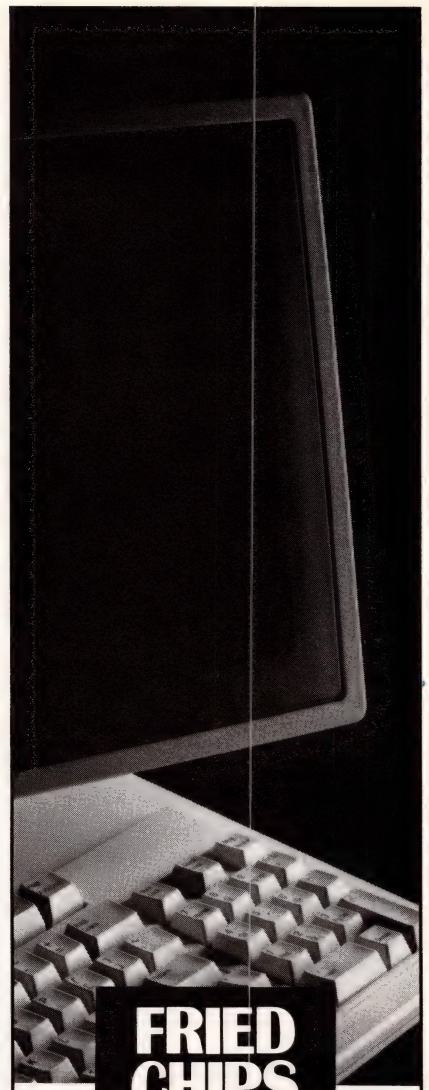
PGA SOCKETS

- *Feature zero insertion force*
- *Handle arrays as large as 21 x 21*

Series 650 pin-grid-array (PGA) sockets are zero-insertion-force devices that accommodate arrays ranging from 10 x 10 to 21 x 21 pins. The sockets feature normally closed, dual-beam, beryllium-copper contacts. The contacts are plated with 30 μ m. of select gold over 50 μ m. of nickel. Designed for compatibility with fully automatic loading/unloading operations, the sockets feature a chamfered lead-in area, which eases lead insertion. The socket insulators are made with a thermoplastic material that carries a UL 94V-0 rating. Operating range extends to 150°C. \$16.99 (1000) for a 10 x 10 socket.

Wells Electronics Inc., 1701 S Main St, South Bend, IN 46613. Phone (219) 287-5941.

Circle No 356



FRIED CHIPS.

The most serious cases of data indigestion in computer systems are brought on by damaging spikes and surges which cause system data loss and catastrophic damage to equipment.

TransZorb® suppressors from General Semiconductor Industries provide high surge capability, extremely fast response time and low clamping voltage.

Ask for the broad range of modular assemblies (120K232, CPP52-SP CPP52-PP, CPE80, MB80, 422B, 422E, 232B, 232E) or transient voltage suppression diodes like the 5-volt-and-up ICTEs.

You can't totally isolate your system from the kind of menus that make you feel queasy. But you can do the best job of protecting sensitive microprocessor-controlled systems with protection from GSI.

Call GSI today for Applications assistance at (602) 968-3101.



©1989 General Semiconductor Industries, Inc.

CIRCLE NO 123

VISHAY Electronic Components Group Will Satisfy All Your Resistor Needs

ANGSTROHM

Power Rheostats

MIL-R-22 Approved

Resistance Range from 0.5Ω to 10kΩ

Resistance Tolerance ±10%, others available

Power Rating 12.5, 25, 50, 100, 150 & 300 watts
(300°C rise in free air)

Types MP06, MP10, MP15, MP25, MP30, MP40.

Precision Metal Film

MIL-R-10509 & MIL-R-55182 Approved

Over 1.234 billion unit failure rate hours to MIL-R-55182 without a single failure.

Hermetically Sealed Styles RNR/RNN/RNC,
Characteristics C & E, Established Reliability.

Resistors, Networks, Specials.

Circle 168

DALE

Precision & Commercial Components Military Trimmers - Techno Division

MIL-R-22097, MIL-R-27208,

MIL-R-39015 & MIL-R-39035 Approved

Surface Mounted Components, Wirewound, Metal Oxide & Carbon Film Resistors, Thick & Thin Film Chip Resistors, Resistor & Resistor/Capacitor Networks, Commercial Trimmers, Thermistors, Inductive Components, Transformers, Clock Oscillators, Connectors, Plasma Display, Touch Panels.

Circle 169

ELLIOTT/JORDAN

Precision Wirewound

Temperature Sensing and Compensating,
Hermetically-Sealed, Special TCR,
Four Terminal, Low Reactance.

**Resistors, Printed Circuit, Axial & Radial
Leaded, 4 Terminal Molded, Silicone
Molded/Coated, Ultra-Miniature,
Surface Mount.**

Circle 170

OHMTEK

Thin Film

MIL-R-55342 Approved, Char. E, K Chips

TCR to 5ppm/°C

Tracking to 1ppm/°C

Ratio Tolerances to 0.005%

Resistance Range 50Ω to 10MΩ

**Precision Custom & Standard Networks
SIPs, DIPs, LCCs, Flatpacks, Small Outline
Custom Arrays, Silicon & Alumina Chips for
Hybrids, Microwave Substrates.**

Circle 171

ULTRONIX

Precision & Power Wirewound

MIL-R-26, MIL-R-93, MIL-R-18546,

*MIL-R-39005 (RBR), MIL-R-39007, MIL-R-39009,
MIL-R-55182 & MIL-R-83401 Approved*

Established Reliability, Temperature Sensing,
Ultra-high Stability, Hermetically Sealed.

**Resistors, Printed Circuit, Axial &
Radial Leaded, 4 Terminal Molded,
Silicone Molded/Coated, Ultra-Miniature,
Surface Mount.**

Circle 172

VISHAY

Precision Bulk Metal- Foil

MIL-R-122, MIL-R-22097,

MIL-R-55182/9 & MIL-R-83401 Approved

TCR to 0.1ppm/°C

TCR Tracking to 0.2ppm/°C

Absolute Initial Resistance to 0.001%

Resistance Ratio Stability to 0.001%

Load Life Stability to 0.0025%

Shelf Life Stability to 0.0005%

Thermal EMF to 0.03V/°C

**Resistors, Trimmers, Networks, Chips,
Surface Mount, Specials.**

Circle 173

VISHAY Electronic Components Group

...a VISHAY Company

63 Lincoln Hwy. ♦ Malvern, PA 19355 ♦ (215) 644-1300 ♦ FAX (215) 296-0657 ♦ Sales FAX (215) 640-9081



SWITCHES

THAT TAKE THE

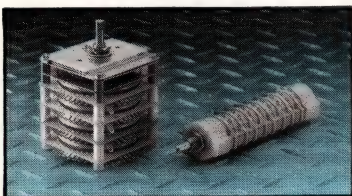
SHAKE, RATTLE, AND ROLL

**...and the
punch, the grit,
the moisture, the
temperature
swings.**

Electroswitch Rotary Switches are on the QPL because they not only meet every applicable mil spec, but they've also been proven over years of field use.

These shock-proof switches can carry up to 10 amperes and utilize reliable, low resistance, dual wiping, spring loaded moving contact arms. Add to that, gold plated contacts, stainless steel shafts, and glass fibre reinforced epoxy decks and you have absolute dependability.

Available in 3 styles with up to 48 positions make before break, or 24 positions break before make.



ELECTROSWITCH SOUTHERN OPERATIONS
UNIT OF ELECTRO SWITCH CORP

P.O. Box 41129 Raleigh, NC 27604
(919) 833-0707 FAX: (919) 833-8016

CIRCLE NO 126

COMPONENTS & POWER SUPPLIES



PROXIMITY SENSOR

- Has a 6-in. to 60-ft detection range
- Available in a choice of housings

The ISU-101 proximity sensor, which features a 6-in. to 60-ft sensing range, has a resolution of 0.007 in. and accuracy of $\pm 5\%$. The sensor is available in plastic or stainless-steel enclosures that are designed to mate with 2-in. NPT fittings for easy mounting in standard fixtures and flanges. The unit offers factory-set or user-programmable detection limits. The sensor can include one or two limit relays and is user programmable using a companion SPU programming unit. Once programmed, the ISU-101 stores its limit settings in permanent memory and operates the internal relays based on these limits. \$199.

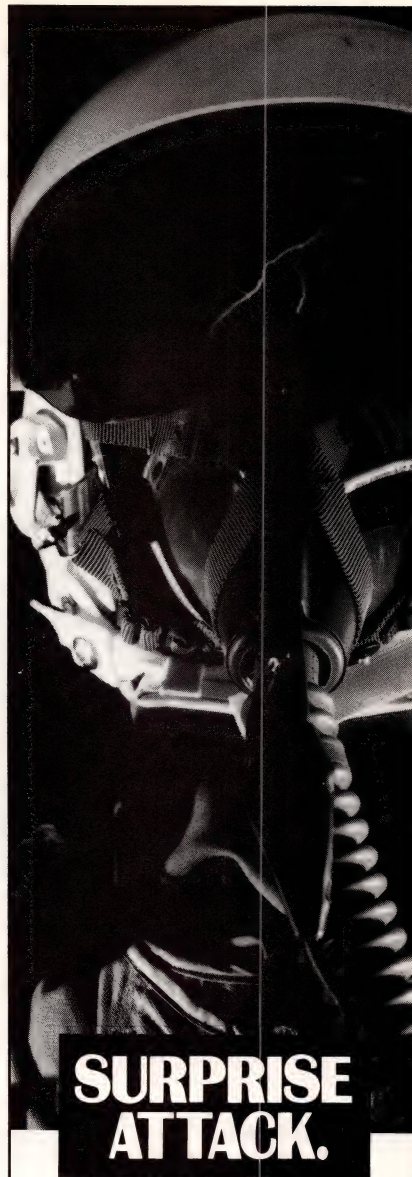
Contaq Technologies Corp., 15 Main St, Bristol, VT 05443. Phone (802) 453-3332.

Circle No 357

MOTOR DRIVER

- Drives a choice of motors
- Has a 10^6 -hour min MTBF

The high-voltage motor driver (HVMD) drives commercially available 220V, 3-phase induction motors or 300V brushless dc motors. It runs directly from a 300V dc bus and can deliver as much as 1 hp. Measuring $2 \times 4 \times 6$ in., the HVMD uses an externally generated signal whose 0 to 5V range controls motor speed over a 0 to full rpm range. The driver has a 10^6 -hour min MTBF and conforms to IEC 950, UL, TUV, and CSA standards. Other features include a PWM algo-



There's a defense against electronic-crippling transients. It's the immediately available, full range of MIL-standard, high-rel transient voltage suppression (TVS) diodes and megadiodes from General Semiconductor Industries.

The "General" has been serving defense industries for many years with TVS protection devices that deliver high surge capability, extremely fast response time and low clamping voltage.

Ask for GSI TransZorb® megadiodes (PHP, 704, 60KS and 90KS) and JAN, JANTX, JANTXV TVS diodes in DO-13 packages.

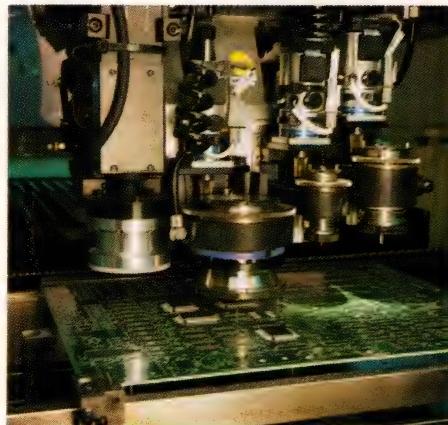
Call GSI today for Applications assistance at (602) 968-3101. And keep the forces of nature from making a preemptive strike on your sensitive electronics equipment.



©1989 General Semiconductor Industries, Inc.

CIRCLE NO 124

Tomorrow's manufacturing technologies today... without the investment.



Philips Circuit Assemblies is your leading source for custom printed circuit board assemblies, subassemblies and complete box-level contract manufacturing of your electronic products.

We're specialists in PC board assembly, committed to long-term service to customers.

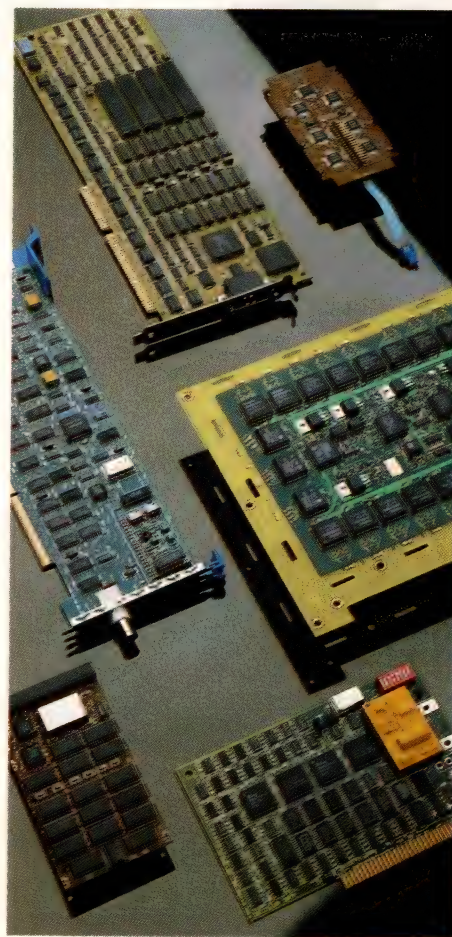
We'll work with you at any stage of product development — design the board to your specifications, adapt your existing circuitry to higher-density configurations, or reduce circuit size to meet system packaging goals.

Fast, economical solutions.

Our high-speed, flexible placement equipment can meet your most difficult demands — including high pin-count, fine-pitch placement. You take advantage of state-of-the-art technologies immediately, while reducing capital investment and limiting on-hand inventory costs.

Philips Circuit Assemblies provides you with both high-volume and low-volume turnkey manufacturing with total test capabilities — including in-circuit, functional, and burn-in. In addition, custom-designed hardware and software test systems can be developed for your specific requirements.

To learn more, write for our capabilities catalog: Philips Circuit Assemblies, A Division of North American Philips Corporation, Corporate Advertising, 2001 W. Blue Heron Blvd., P.O. Box 10330, Riviera Beach, FL 33404, or call 1-800-522-7752 (in Wisconsin, dial 414/785-6359).



Philips Circuit Assemblies



IEEE 488

for PC/AT/386 & PS/2

Compare the features!

IOtech Personal488

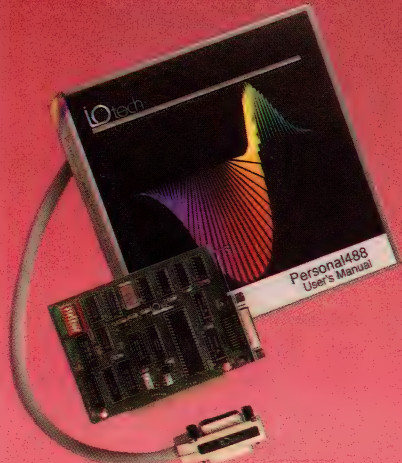
National Instruments PCIIA

\$395	\$395	IEEE 488 board with Quick BASIC & BASICA driver for PCs and compatibles
✓	✓	BASIC ON SRQ GOSUB capability
✓	✓	IEEE printer/plotter redirection utilities
✓	✓	Compatible with Windows 286 & 386
✓	✓	Compatible with IBM GPIB board
✓	N/A	DMA beyond 64K segment boundaries
✓	N/A	BASIC ON ERROR GOSUB capability
✓	N/A	Instrument control directly from DOS
✓	N/A	Borland Quattro spreadsheet support
✓	N/A	DADISP waveform spreadsheet support
✓	+\$495	Lotus 1-2-3 spreadsheet support
✓	+\$495	Lotus Symphony spreadsheet support
✓	+\$100	On-board crystal oscillator
✓	+\$50	Turbo BASIC support
✓	+\$50	True BASIC support
✓	+\$50	Microsoft C support
✓	+\$50	Microsoft Quick C support
✓	+\$50	Aztec C support
✓	+\$50	TURBO C support
✓	+\$50	Microsoft FORTRAN 4.0 support
✓	+\$50	TURBO Pascal support
✓	+\$50	8086 assembler support

\$395 \$1,235 Total

Add \$100 to each for IBM Micro Channel PS/2 support.

If you already own a National Instruments PCII or PCIIA, IBM GPIB, or any NEC 7210-based IEEE board, **Driver488** from IOtech provides the software features above for only \$195. Also, our **GP488B** IEEE board at \$295 is an economical replacement for any of the IEEE boards listed above.



Call or send for your
FREE Technical Guide

IOtech

(216) 439-4091

Telex 6502820864 • Fax (216) 439-4093

IOtech, Inc. • 25971 Cannon Road • Cleveland, Ohio 44146

London (0734) 861287 • Paris (1) 34810178 • Milan (02) 4120360 • Brussels (02) 3848062
Zurich (01) 8219444 • Vienna (0222) 253626 • Garmisch (01) 8303333
Linköping (01) 3110140 • Helsinki (03521) • München (089) 710020 • Oslo (02) 649070
Copenhagen (02) 804200 • Madrid (91) 4027060 • Lisbon (01) 4103420 • Seoul (02) 678 7457
Tel Aviv (03) 491 922 • Melbourne (03) 5793622 • Toronto (416) 6740444
Products listed are trademarks of the respective manufacturer.
Comparison based on product information available January 1, 1989.

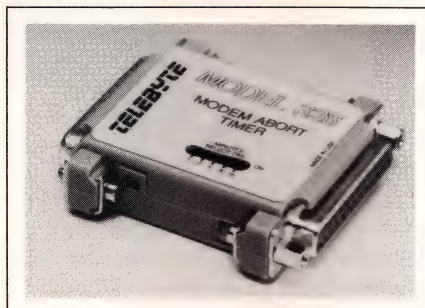
CIRCLE NO 127

COMPONENTS & POWER SUPPLIES

rhythm during reduced-speed operation, low voltage disable, short-circuit protection, and overload clamp with timed delay shutdown. From \$250 (5000).

Cambridge Aeroflo Inc., 900 Mt Laurel Circle, Shirley, MA 01464. Phone (508) 425-2346. FAX 508-425-2338.

Circle No 358



ABORT TIMER

- Prevents modem tie-up
- Features 2-way monitoring

Model 328 modem abort timer connects between modem and computer ports. It monitors the communications interchange and disconnects the hookup when it detects zero data flow. The timer features a switch-selectable 1- through 16-minute timed interval from initial dial-up to modem abort. It determines whether there has been a transmit data (TD) or a receive data (RD) signal during the timed interval. If it detects no TD or RD signal during the timed interval, the 328 drives the data carrier detect (DCD) signal low for 5 sec. In turn, the host releases the line, freeing the modem to receive new incoming calls. The unit supports synchronous and asynchronous communications and is transparent to full-duplex data and protocol signals. The module comes with male and female DB25 connectors to ease termination procedures. \$87.

Telebyte Technology Inc., 270 E Pulaski Rd, Greenlawn, NY 11740. Phone (516) 423-3232. FAX 516-385-8184.

Circle No 359



NO ANSWER.

In a world that runs on communications, inferior system protection is no answer. That's why leading datacom and telecom system manufacturers specify products with transient voltage protection devices from General Semiconductor Industries.

Long the leader in transient voltage suppression (TVS) board and system level protection, GSI offers TVS diodes in low voltages (5.0V to 50V) and assemblies like the 120KMP1 and the MP11 and MP45. All designed specifically for datacom and telecom protection.

GSI TransZorb® TVS protection devices deliver high surge capability, extremely fast response time and low clamping voltage.

Call GSI today for Applications assistance at (602) 968-3101.



©1989 General Semiconductor Industries, Inc.

CIRCLE NO 125

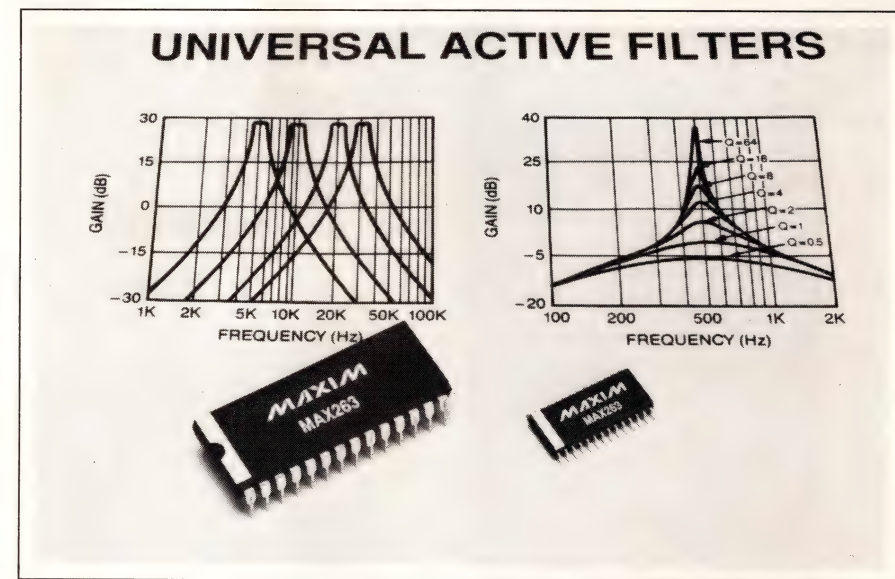
NEW PRODUCTS

INTEGRATED CIRCUITS

MONOLITHIC FILTERS

- Feature pin programmability
- Have 0.4-Hz to 140-kHz frequency range

The Max263 and Max264 are pin-programmable, switched-capacitor monolithic filters with center-frequency input ranges from 0.4 Hz to 57 kHz (Max263) and 1.0 Hz to 140 kHz (Max264). Each part has two programmable second-order filter sections, which you can use to implement lowpass, highpass, bandpass, allpass and band-reject filters. Each filter has three outputs (lowpass, bandpass, and highpass/notch) that you can use simultaneously. The center-frequency range is programmed by a 6-bit digital input. The selectivity (Q) for each section is programmed by a 7-bit digital input, which allows a range of Q from 0.5 to 64. The low noise (100 μ V rms) of the devices represents

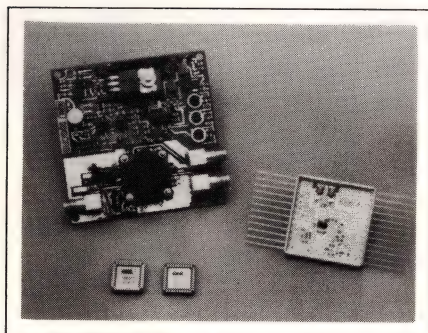


less than $\frac{1}{2}$ LSB in a 12-bit data-acquisition system. PC-based, menu-driven software is available that reduces the design time of nth-order filters to minutes. Both of the filters are available in 24-pin DIPs,

ceramic DIPs, and SOIC packages. From \$6.50 (1000).

Maxim Integrated Products, 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 370



CLOCK-RECOVERY IC

- Fabricated in GaAs
- Has 50M- to 800M-bps NRZ data rate

The 16G041-H is a GaAs hybrid circuit that forms a complete PLL clock-recovery and data-retiming/regeneration subsystem. The IC integrates the 16041 clock-and data-recovery monolithic IC with a high-performance loop filter and other components. It can synchronize an internal VCO directly to an incoming digital data stream while simultaneously retiming and regenerating the data stream. The device provides a 50M- to 800M-bps NRZ

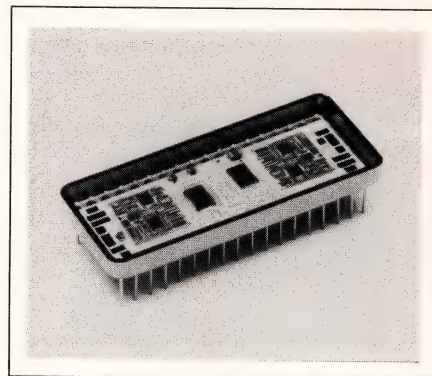
data rate and comes in a 1.25×1.25 -in. surface-mount package. If you want to create a different subsystem, the 16G041 monolithic IC and the 90GCRB demonstration board are available separately. 16G041-H, \$247 (100); 16G041, \$135 (100); 90GCRB, \$845.

GigaBit Logic, 1908 Oak Terrace Lane, Newbury Park, CA 91320. Phone (805) 499-0610. FAX 805-499-2751.

Circle No 371

D/R CONVERTER

- 16-bit resolution
 - Pin-programmable gain control
- Packaged in a 36-pin double DIP, the DRC-11522 contains two D/R (digital-to-resolver) converters in one hybrid module. Except for the 16 digital lines, each channel of the DRC-11522 is independent. The module features pin-programmable gain control, 16-bit resolution, an accuracy of ± 1 minute, and a scale-factor variation of 0.05%. The mod-

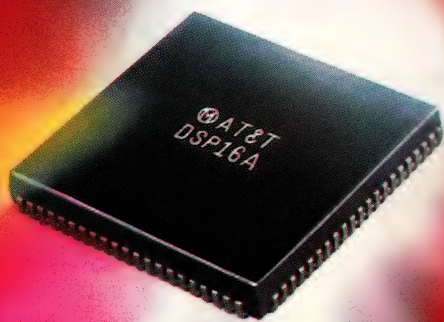


ule also includes a dc-coupled reference and double-latched inputs. With a dc reference input, the DRC-11522 acts as a digital-to-sin/cos dc converter. With the reference input proportional to the radius vector, the device converts polar-to-rectangular coordinates. It operates over -55 to $+125^\circ\text{C}$ and is available screened to MIL-STD-883. From \$237.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 563-5678. FAX 516-567-7358.

Circle No 372

Tomorrow's telecom designs
are now within your reach.



AT&T DSPs, packed with powerful telecom capabilities, give you the design flexibility you need to turn product dreams into market realities.

Whatever your application—PBX, modem, central office equipment—we can help you make it work. With the fastest fixed point chip on the market—our 25ns DSP16A. With the multi-functional architecture of our floating point DSP32/32C. And with application notes to help complete your solution.

Our DSPs let you implement up to 32 Dual Tone Multi-Frequency receivers (DTMFs) on a single chip. Build in echo cancellation for superior long-distance transmission. Or implement a full duplex CCITT-standard ADPCM transcoder, to double the data on a T1 line. Plus, AT&T DSPs permit a glue-free interface with all AT&T codecs.

Design time? Our application notes will get you by every snag. We offer

simulators, assemblers, and linkers for our full DSP line. A C-compiler for our floating point devices. An application library with math, FFT and filter functions. And Hewlett Packard is developing an emulator for our DSP32C.

You'll also have the full support of AT&T's Field Application Engineers, Technical Support Group, and AT&T Bell Laboratories' DSP designers.

For more on the DSPs designed for design-in success, just call AT&T Microelectronics at **1 800 372-2447**.

**The
components
of success.**



AT&T

The right choice.

20-PIN PAL-TYPE IC

- Replaces SSI/MSI logic
- Has zero-power capabilities

Consuming less than 100 μA in the standby mode, the PLC18V8Z-35 logic device is a functional replacement for SSI/MSI logic and a superset of all widely used 20-pin PAL-type devices. The IC's power con-

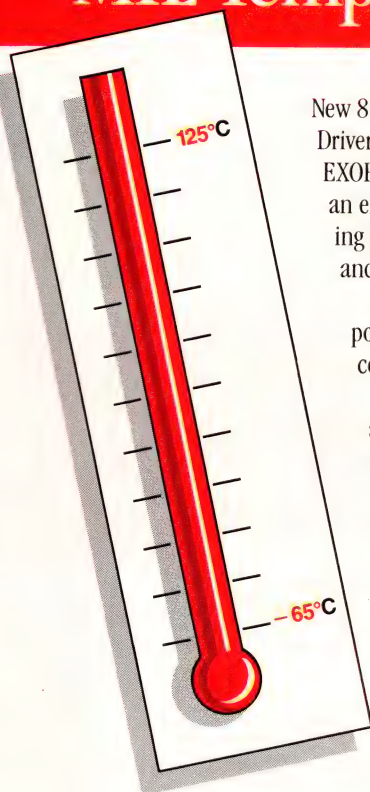
sumption increases linearly at a rate of 1.5 mA/MHz while in operation. When operating at 20 MHz, the PLC18V8Z consumes less than one-quarter of the power needed by conventional PLA devices. Its universal architecture facilitates combinatorial and sequential (registered) operations. The part has 18

inputs, eight of which are dedicated; you can program each of the eight output macrocells as an input, combinatorial, or registered output, or as a buried register with feedback. The propagation delay of the device is 35 nsec. \$3.25 (1000).

Signetics Corp., 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-2000.

Circle No 373

NEW! Low Power Digital GaAs ICs for High Speed MIL Temp systems



Proven reliability over MIL Temp ranges.

New 8-bit Shift Register, Line Driver/Clock Driver, Line Receiver and Dual Exclusive EXOR/NOR Gate. With speeds to 5 Gb/s and an extended temperature range, NEC's growing family of GaAs ICs are ideal for military and fiber optic applications.

And with ECL compatibility and low power dissipation, you get parts that are consistent, reliable, and easy to work with.

Give us a call. We have GaAs ICs available in both chips and packages, a fully equipped engineering facility, and the experienced applications support it takes to get your designs off paper and into production.

NEC technology and quality—and CEL service. It's a powerful team. Put it to work for you.

FREE DATA FOR DESIGNERS

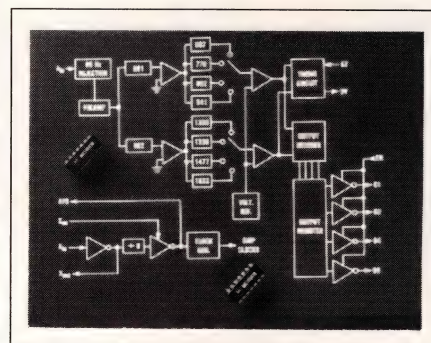
For product data and information on our Evaluation Kits and Prototyping Boards, call, write, or circle the number below.

California Eastern Laboratories

Headquarters (408) 988-3500
3260 Jay Street, Santa Clara, CA 95054
Western (408) 988-7846 Eastern (301) 667-1310
Central (312) 655-0089 Canada (613) 726-0626

© 1989 California Eastern Laboratories

NEC



DTMF RECEIVER

- Detects all 16 standard digits
- Uses inexpensive 3.58-MHz crystal

The MC145436 DTMF receiver/decoder decodes all 16 standard DTMF tones over -32 to -2 dBm in ISDN applications. The device contains a filter and decoder for detection of tone pairs conforming to the DTMF standard with a 4-bit hexadecimal output code. It has a 3-state output enable and uses a 3.58-MHz crystal or an external clock for timing. Other features include built-in 60-Hz and dial-tone rejection, and guard-time controls to improve speech immunity. The SSI-204 pin-compatible MC145436 comes in a 14-pin DIP. \$3.25 (1000).

Motorola Inc., MOS IC Div, Box 6000, Austin, TX 78762. Phone (512) 928-6880.

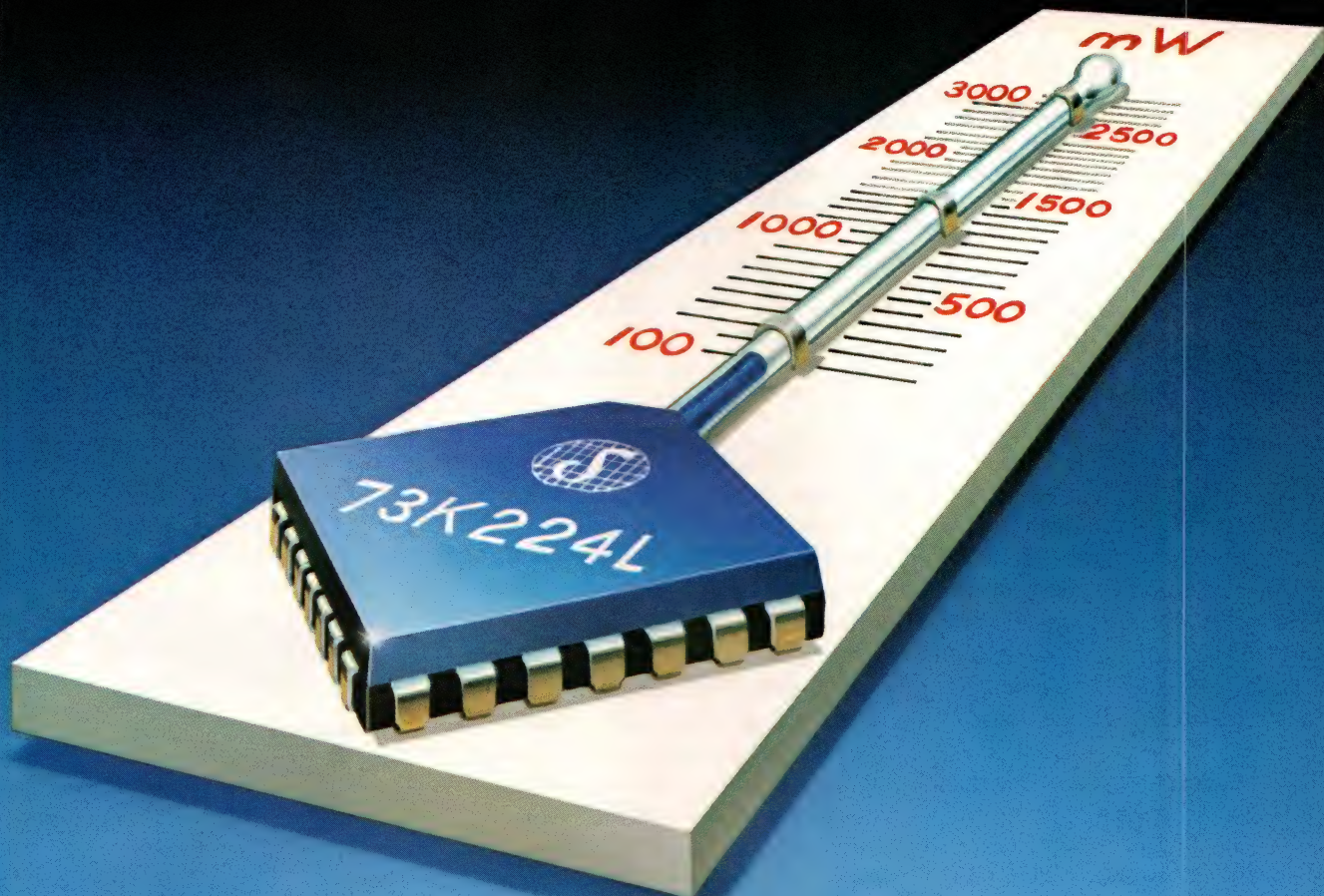
Circle No 374

S/H AMPLIFIER

- Features 16-bit accuracy
- Has 3.5- μsec acquisition time

The AD1154 sample-and-hold amplifier maintains 16-bit accuracy in

CIRCLE NO 129



A new low in modem ICs.

The Industry's First Single-Chip Low-Power Modem

Silicon Systems has achieved a new low in modem ICs: the first 2400-BPS single-chip modem that uses less than 120mW of power from a single 5-volt supply. A new low that others can't match with their modem IC solutions that burn up as much as 3000mW of power.

The new SSI 73K224L goes where no modem IC has gone before. It goes into systems too space and power-limited to accommodate the multiple chips and power supplies that other solutions require. Now this single 2400-BPS chip from Silicon Systems does the whole job. With DSP as well as all the V.22 bis modem functions packed into it, it only

requires half the space of other solutions. It results in far greater reliability, lower cost, and smaller size in the end product.

The SSI 73K224L is totally pin and register-compatible with a whole family of other low-power K-Series devices available from Silicon Systems. The compatibility offered by this family of chips allows the user to develop several different end-products from one basic design, and it protects those designs from obsolescence by affording one-chip field upgrading.

SSI 73K224L users can now easily integrate 2400-BPS modem capability into their power-limited systems, adding

the benefits of built-in high-speed communications to their products.

CALL NOW!
(714) 731-7110, Ext. 3575

For more information on this exciting new 2400 BPS low-power modem, or our complete line of other low-power modem ICs, contact Silicon Systems or your local representative or distributor today.

Silicon Systems, Inc.
14351 Myford Road, Tustin, CA 92680
Ph: (714) 731-7110, FAX: (714) 669-8814.
European Hdq. U.K. Ph: (44) 7983-2331

silicon systems®

Circle 130 for Product Information

INTEGRATED CIRCUITS

high-resolution data-acquisition systems at a cost that is 40% lower than competitive devices, according to the manufacturer. The amplifier's guaranteed maximum nonlinearities in sample-and-hold modes is ± 0.003 and $\pm 0.00076\%$, respectively (B grade). Other features include a 3.5- μsec typ (5- μsec max) acquisition time to $\pm 0.00076\%$ of 20V; a 150-psec aperture uncertainty; and an 80-nsec aperture delay. The hybrid IC's 10V/ μsec slew rate and its 120-kHz (min) full-power bandwidth provide the range needed in peak-detection circuits. The AD1154 is packaged in a 14-pin metal DIP for use over the -25 to $+85^\circ\text{C}$ temperature range, and is available in two grades. A and B grades have maximum hold-mode nonlinearities of ± 0.0015 and $\pm 0.00076\%$, typical acquisition times of 5 and 3.5 μsec , and maximum droop rates of 0.1 and 0.05

$\mu\text{V}/\mu\text{sec}$, respectively. \$42 and \$49.50 (100).

Analog Devices Inc., Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-3532. TLX 924491.

Circle No 375

ANALOG SWITCH

- Contains eight spst switches
- Has $\pm 15\text{V}$ input range

The DG485 analog switch has a serial input control that lets you connect any combination of the device's eight spst switches to a common output line. The device features a maximum on-resistance of 85Ω and low leakage currents for improved signal accuracy. TTL and CMOS compatible, the DG485 has a switching time (t_{on}) of 200 nsec. The IC operates with either bipolar ($\pm 15\text{V}$) or unipolar (12V) supplies and dissipates less than 105 μW .

8-Time Oversampling Digital Filter for Audio System

This Molygate (モリゲート[®]) CMOS digital filter, SM5813AP/APT contains two channel filters providing passband ripple of $\pm 0.00005\text{dB}$ and stopband attenuation of over 110dB. It accepts 16-bit serial data input and delivers 16, 18 or 20 bits serial output data. Many other unique features are also provided in this 28-pin DIP filter.

For complete product information and other digital filters available in our stock, please contact Greg Branch, Sales Director.



SEPONIX

2151 O'TOOLE AVE., SUITE L
SAN JOSE, CALIFORNIA 95131
TEL: 408-922-0133 • 1-800-237-4590 • FAX: 408-922-0137

モリゲート[®] is a registered trademark of NPC Ltd. α

CIRCLE NO 131



Not A Spec Of Difference.

We build components precisely to mil-specs but skip the expensive government QPL red tape. So you get mil-spec quality without the mil-spec price. For a free catalog and your nearest distributor, call 1-800-247-8256.



©1989 E.F. Johnson Company. A company of Diversified Energies Inc.

CIRCLE NO 132

Cathode Ray Tubes

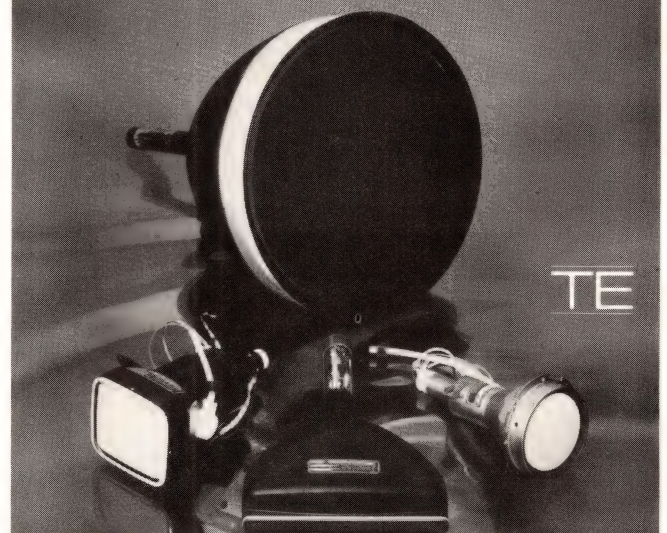
Thomas Electronics cathode ray tubes ... designed for Military, Commercial and Industrial applications ... from the most sophisticated avionics and photo-recording to the general computer terminal and medical display applications.

Four production facilities to serve you best in Wayne, NJ — Los Angeles, CA — and Clyde, NJ.

Send for our new full color catalog, or contact us with your specific requirements.

THOMAS ELECTRONICS

100 Riverview Drive, Wayne, NJ 07470 / 201-696-5200
TELEX: 310-685-3326 / FACSIMILE: 201-696-8298



CIRCLE NO 133



SENSR
CNTCT

HOOK
VERFY

ACSTS
REF
MARK

NVG COMPATIBILITY FROM THE PILOT'S POINT OF VIEW.

Day or night, pilots see exactly the information they need with Korry's new NVG-compatible switchlights and panels. Clearly and comfortably, without hot spots or light leaks. All thanks to the most uniform brightness—and the truest red—in the entire industry.


Today, Korry NVG-compatible switchlights are being used by pilots flying the Black Hawk HH-60H, the world's first production-version MIL-L 85762-compliant Helicopter Combat System.

Even in direct sunlight, pilots see sharp, high-contrast legends of green, yellow, and red, through ANVIS or Cat's Eyes goggles.

Look at NVG-compatible switchlights and panels from the pilot's point of view. We think you'll agree on Korry, today the leader in NVG—and for over fifty years the leader in all customized illuminated cockpit information and control systems. Call (206) 281-3563 today for additional information.

CRTON KORRY

CIRCLE NO 59



With RadCELL™ 120, it's not a call for help. It's an answer.

Silicon On Sapphire. It's the technology to count on when you're faced with a demand for radiation-hardened performance.

And Rockwell International now gives you easy access to this state-of-the-art capability through a family of CMOS/SOS standard cells.

The RadCELL 120 family gives you a library of more than 100 cells, hard macros and compiled functions. Offering packaging flexibility and production to both Class B and Class S specs. At a cost only about 60% greater than CMOS alone.

Equally important, Rockwell

SOS technology makes RadCELL easier to design with than other ASIC programs. So you save time and money, right from the start.

RadCELL offers effective channel lengths of just 1.2 microns, achieving one nanosecond gate delay and high density. And you can get the same benefits in VHSIC-compatible CMOS ASICs with Rockwell's MilCELL™ family. In addition, no matter what type of ASICs your project requires, you can depend on Rockwell's Microelectronics Technology Center as a stable source of supply. We've been responding to the special require-

ments of government programs for more than 20 years.

Whether you're designing for air, space, land or sea, Rockwell can enhance your ASIC options. Contact us at (714) 833-4133. We'll answer your call for help, on the double.

Microelectronics Technology Center



Rockwell International

...where science gets down to business

Aerospace/Electronics/Automotive
General Industries/A-B Industrial Automation

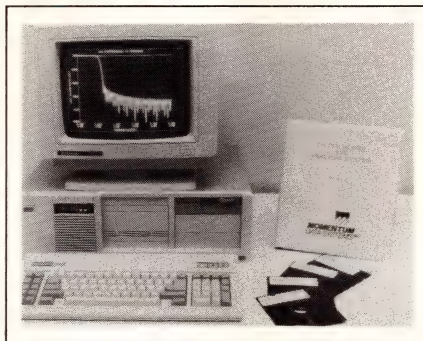
NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

FILTER-DESIGN TOOL

- Lets you design and analyze FIR, IIR, and Equiripple filters
- Can automatically generate code for 16-or 32-bit DSP chips

Filter Design and Analysis System (FDAS) 2.0 lets you design FIR (finite impulse response), IIR (infinite impulse response), and Parks McClellan Equiripple FIR filters. The FIR and Parks McClellan packages handle lowpass, highpass, bandpass, bandstop, differentiator, and multiband filters; an FIR filter can have as many as 2048 taps, and a Parks McClellan filter as many as 400 taps. The Parks McClellan package also handles Hilbert transformers and arbitrary-magnitude filters. The IIR package handles lowpass and highpass filters with as many as 40 taps, and bandpass and bandstop filters with as many as 80 taps. The system-analysis package



lets you determine the magnitude, phase, group delay, impulse response, pole/zero locations, and step response of a given transfer function. You can supply the transfer function as a ratio of polynomials, zeros, and poles, or as the product of second-order sections. When you've completed your design, you can invoke a code generator that generates assembly code for AT&T DSP16 or DSP32 processors, or for TI's TMS320 series, or for Mo-

torola's DSP56001 processor. To run the FDAS, you'll need an IBM PC, PS/2, or compatible that is equipped with 640k bytes of RAM, has at least 800k bytes of free hard-disk space, and runs PC-DOS 2.0 or higher. FDAS Version 1 (a subset of the features), \$495; FDAS Version 2 (the full set of features), \$895; code generators for the DSP16 and DSP32, \$200 each.

Momentum Data Systems Inc., 1520 Nutmeg Pl, Suite 108, Costa Mesa, CA 92626. Phone (714) 557-6884. FAX 714-557-6969.

Circle No 380

SECURITY SHELL

- Protects your computer against viruses
- Includes self-test program

The Integrity Shell is a self-testing command interpreter (shell) for PC-

Text continued on pg 234



ESK-U SERIES

SWITCHING POWER SUPPLIES

AC 110/220V (selectable)

EMI: FCC/VDE 0871 class "B"

Switches at 100 kHz

2 year warranty



QUALITY NO. 1

- 20, 30, 50, 70, 80W dual and triple outputs
- Line regulation 0.4%
- Typical operating efficiency 72%
- Load regulation 0.8% no load to full load
- Minimum hold up time: 20 milliseconds

VDE approved 50W dual and triple models available (VSK Series)

*20 and 30 watt models designed to meet UL/CSA standards

Volgen America Inc. 39650 Liberty Street, #325, Fremont, CA 94538
(415) 498-5950 FAX (415) 498-5954

CIRCLE NO 136

Be An Author!

When you write for EDN, you earn professional recognition. And you earn \$75 per published magazine page.

EDN publishes how-to design application information that is read by more than 137,300 electronics engineers and engineering managers worldwide. That's an audience that could belong to you.

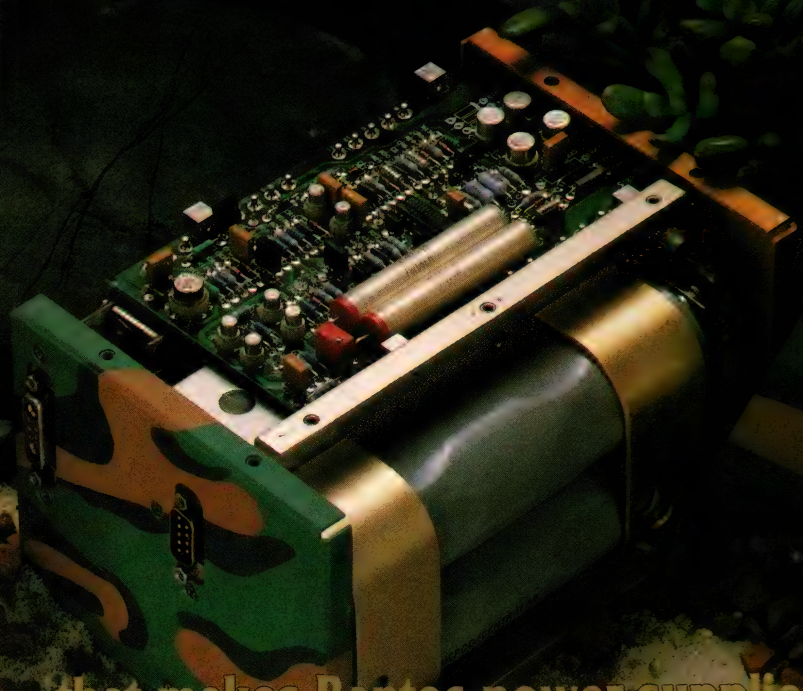
If you have an appropriate article idea, send your proposal and outline to: John Haystead, 275 Washington Street, Newton, MA 02158-1630.

For a FREE EDN Writer's Guide—which includes tips on how to write for EDN and other technical publications—please circle number 800 on the Information Retrieval Service Card.

EDN

First in Readership among Design Engineers and Engineering Managers in Electronics.

It's what you can see...



...that makes Rantec power supplies FULL-MIL™ qualified.

- **FACT:** DOD is mandating higher standards for solderability, workmanship and construction (MIL-STD-2000 & WS6536).
- **FACT:** Newly revised NAVMAT P4855-1A reflects the military's determined effort to eliminate negligence in power supply design and construction.
- **FACT:** Encapsulation hides inferior commercial practices that corrupt FULL-MIL power supplies (the HALF-a-MIL™ trap).

You really should be able to look inside a power supply to know if it conforms to FULL-MIL specifications. With Rantec FULL-MIL **standard power supplies**, you can easily open the cover— with a screwdriver, not a can opener. You immediately see that the board can be replaced— without dissolving goop and removing wires. Instead you'll find modular construction, with plug-in boards and a separate EMI section. Even I/O connectors are integral parts of the internal assemblies— no wires.

Upon closer examination, you'll see that Rantec FULL-MIL power supplies, as a minimum, utilize JAN-type semi's and established-reliability passive components. You'll also see that Rantec military power supplies are fully compliant with MIL-STD-454 for design, workmanship and materials. And you'll certainly appreciate that Rantec FULL-MIL devices are available without lengthy lead times, costly non-recurring engineering charges and other disappointments associated with customs.

Don't be afraid to take a look inside your MIL-SPEC power supply because it's what you can see that makes the device FULL-MIL. Insure power supply reliability and top system performance by specifying Rantec. **Contact us today.**



As a guide to optimizing power in your system design, ask for your **FREE** copy of "HOW TO SPECIFY FULL-MIL SPEC POWER SUPPLIES: A Guide for Getting Around the Traps of HALF-a-MIL Specifications".



r a n t e c

Rantec/Power Systems ■ Division of Emerson Electric Co. ■ Department FS
9401 Oso Avenue, Chatsworth, CA 91311 ■ TEL: (818) 885-8223 ■ FAX: 8189937780.

CIRCLE NO 138

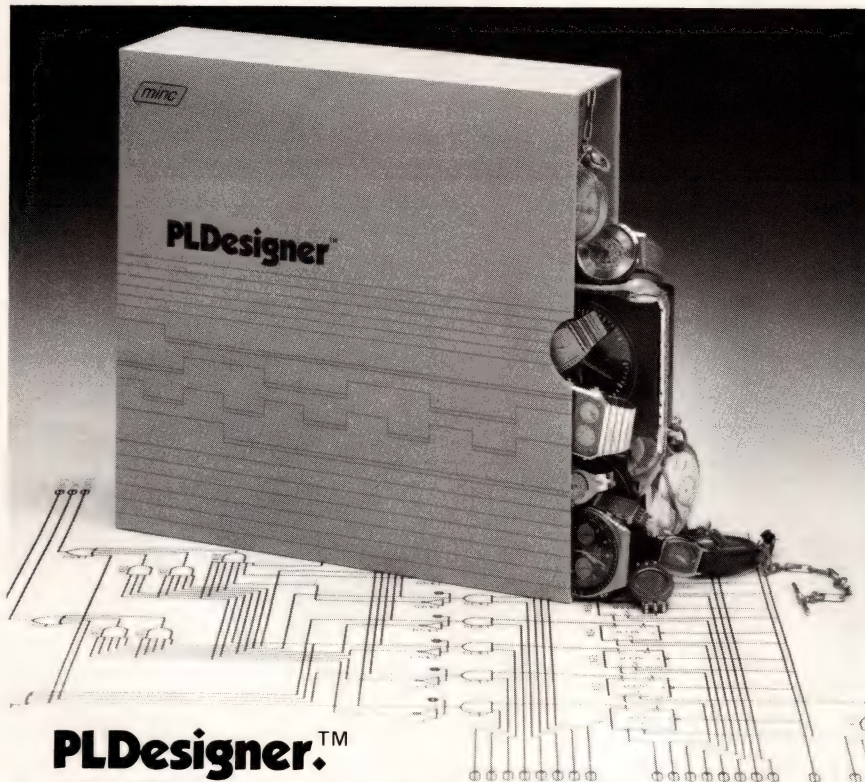
DOS and MS-DOS computers. The shell works with the standard COMMAND.COM and uses a pseudocryptographic checksum to test each program as DOS loads it. If the checksum computed during loading differs from the checksum that the shell originally embedded in the known-good version, the shell

inhibits execution and notifies you that the program has been modified (possibly by a virus). Because Integrity Shell works with, and provides all the facilities of, COMMAND.COM, the shell is totally transparent and cannot cause conflicts with programs of the TSR (terminate-and-stay-resident) type.

Another advantage is that the pseudocryptographic checksum is very difficult for a virus to break, and is therefore more secure than the CRC (cyclic redundancy checksum) used by most antiviral programs. \$59.95.

MDC Software Inc., Box 10589, State College, PA 16805. Phone (814) 238-7321.

Circle No 381



PLDesigner.™ It's like buying time.

Cut weeks from your complex PLD logic designs. PLDesigner design synthesis system combines powerful design entry with automatic design partitioning and device selection to automate time consuming design steps.

With PLDesigner, you enter and simulate the design before device implementation. PLDesigner automatically partitions the design and presents device solutions from a 2500 device library that includes advanced architecture devices. No more manual partitioning, data-book searches or trial-and-error design.

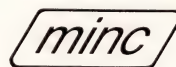
Enter designs using a high-level language, waveforms, or schematic entry to speed design creation. Combine several designs into a system to reduce IC count, cost and PC-board space.

The process is executed automatically...including pin assignments, documentation, test vectors, and programmer setup to get the job done faster.

PLDesigner runs on the PC and is the only PLD solution to be fully integrated into the **Mentor Graphics**, **Cadnetix**, and **Intergraph** environments.

See what it's like to buy time and get your designs to market faster. Call for a FREE demo package.

Minc Incorporated 1575 York Road, Colorado Springs,
CO 80918 719-590-1155



©1988 Minc

CIRCLE NO 139

CASE TOOL

- Lets you simulate a μC and its environment
- Automatically generates MIL-STD documentation

AutoCode/Matrix_x 2.0 provides all of the functions needed to design and implement the software for an embedded-control system. The package unifies a graphic modeling system with engineering analysis, plotting, simulation, real-time code generation, and automatic documentation facilities. The graphic modeling system lets you design and specify the target system; the simulator lets you simulate the operation of the controller and attached peripheral devices. The analytical features let you perform frequency and stability analysis; linear algebra and equation solving; design optimization; and plotting for data visualization. The code-generation module automatically generates full software code from your completed design. The documentation module automatically generates detailed design documentation that conforms to MIL-STD-2167A requirements and creates hypertext links to requirement and testability information. The package runs on VAX, Sun, or Apollo workstations. \$25,000 to \$40,000 for a single workstation, depending on the features you want.

Integrated Systems Inc., 2500 Mission Blvd, Santa Clara, CA 95054. Phone (408) 980-1500. FAX 408-980-0400.

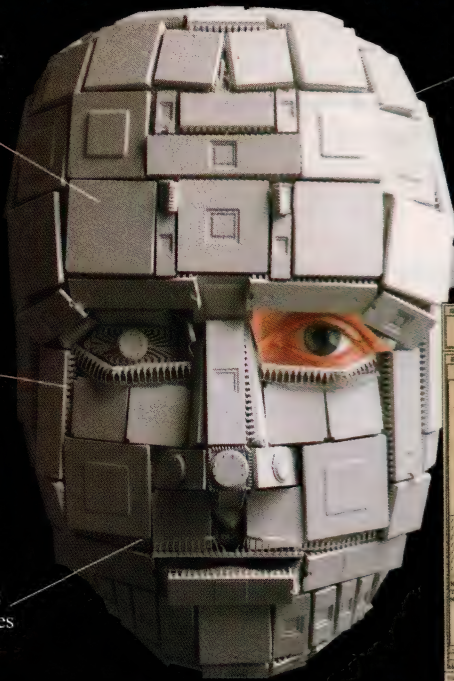
Circle No 382

Simulate the real world.

DesignSim A&D is an open environment accepting your custom models and models from third parties and user groups.

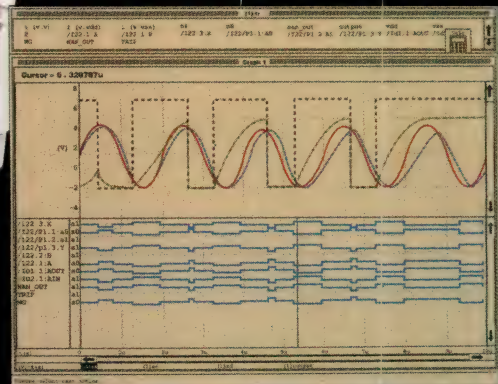
Single and multi-ASIC design are simulated in systems context.

DesignSim A&D's extensive libraries of standard logic, digital and templates support board- and system-level simulation.



Unique DesignSim A&D algorithm reduces simulation run times by allowing analog and digital simulators to schedule efficient time steps and reduce inter-simulator communications.

DesignSim A&D plots analog and digital waveforms with same time base for easy viewing and analysis.



Your product design is brilliant. Inspired. A masterwork.

There's just one hitch.

Your design overwhelms the capabilities of your simulator.

It can't handle your mixed-signal analog-digital circuits even at the ASIC chip level.

Not simultaneously. Not accurately. Not with feedback.

And at the system level? With multiple ASICs? No way.

You need a simulator that can handle real world design.

That's NCR DesignSim™ A&D. This third-generation tool tightly couples analog and digital simulators to ensure the function and performance of mixed-signal ASICs. From the behavioral to transistor level. At the chip to multichip level. All within the system's context.

Plus, you can actually simulate complete systems and subsystems using optional models and templates for standard components, electromechanical devices, motors and sensors.

Imagine how that could shorten the design cycle and boost first-pass chip and system success.

And because DesignSim A&D is fully featured, one system provides many types of analysis such as fault-grading and frequency analysis.

DesignSim A&D is just one benefit of working with NCR's Knowledge-based Engineering Environment (KE²).

To receive a complete information package on DesignSim A&D and KE², call 1-800-334-5454.

Creating value

DesignSim A&D is based on Saber (Analogy) and CADAT (HHB, a subsidiary of Daisy/Cadnetix). ©1989 NCR Corporation. DesignSim and KE² are trademarks of NCR Corporation.



Password : Componic

COMPONIC is the password for a meeting with the world of electronic components. COMPONIC is the password to remember if you want to meet, discover and compare all the electronic components manufactured throughout the world.

COMPONIC (the new name for the INTERNATIONAL ELECTRONIC COMPONENTS EXHIBITION) will take place from the 13th to the 17th of NOVEMBER 1989 at the PARIS-NORD Exhibition Center.

A unique occasion not to be missed.



Componic 89

**THE KEY TO YOUR
COMPANY SUCCESS**

Organisation SDSA : 65, avenue Édouard-Vaillant - F 92100 Boulogne-Billancourt - Tél. : (33-1) 46.08.31.32 - Télex : 633 018 F - Fax : (33-1) 46.08.23.12

Mr. or Mrs. _____

Address _____ Phone: _____

Please send me ☐ Exhibition Leaflet ☐ Pre-catalogue _____



GENERAL DYNAMICS LAND SYSTEMS

Generations from now, when today's state-of-the-art fighting systems have taken their place in armament history books, today's Abbott power supplies will still be operating reliably.

Outfitted for Enhanced Reliability, for example, our new 60 Watt triple-output switching DC-DC converter achieves an MTBF rating up to 600,000 hours; more than 68 years. A single-output model is rated even longer.*

Yet this compact package is fully self contained. It meets the tough EMI limits of MIL-STD-461C. And the punishing environmental specs of MIL-STD-810C and MIL-S-901C.

While the BC60 is brand new, this is no "developmental" power supply. Its topology is identical to our field proven BC100 and BC200 models. Its design integrity is verified through rigorous ESS testing.

We're delivering power supplies for projects critical to America's defense, including MILSTAR, the EH101 helicopter, the TOW missile, INEWS and the F/A-18 Hornet.

For a copy of our 1988 Military Power Supply Product Guide, write us at 2721 S. La Cienega Boulevard, Los Angeles, CA 90034. (800) 556-1234 XT9; CA (800) 441-2345 XT9.

*MTBF FIGURES CALCULATED PER MIL-HDBK-217E GROUND.

**Our power supply
is built to
outlast the tank.**



Versatile new 60 Watt switcher measures 5 x 4 x 1.5 inches. Provides outputs of 5, 12, 15, 24 or 28 V dc, from inputs of 18 to 36 V dc. Operating temperature from -55°C to +100°C. Overvoltage protection & short circuit protection standard.

abbott

WHEN RELIABILITY IS IMPERATIVE.™

flected in the displays produced by the other tools. The five modules are XScheme, a schematic-capture module; XBoard, a 2-D drafting and documentation tool; XPlace, which performs automatic or interactive component placement; XRoute, which performs automatic or interactive routing; and XPost, an artwork and plotting postprocessor. The tools and database are directly compatible with the vendor's LedaX Power pc-board-design software, which runs on Apollo, Sun, and VAX workstations. \$8795.

Microtel Pacific Research Ltd, 8999 Nelson Way, Burnaby, BC, Canada V5A 4B5. Phone (604) 294-1471. FAX 604-293-5787.

Circle No 384

C++ COMPILER

- Fully compatible with AT&T's release 2.0 of C++
- Comes bundled with dbXtra, an enhanced window-based debugger

The HCR/C++ compiler is 100% compatible with AT&T's Release 2.0 of C++, and comes bundled with dbXtra, an enhanced window-based implementation of the widely used dbx debugger. HCR/C++ provides all the features of AT&T's Release 2.0, such as multiple inheritance, type-safe linkages, and default-membership initialization. Because the compiler translates all C++ code into C before execution, you can use the dbXtra debugger to examine either the original C++ code or the derived C code during debugging. The documentation includes Stroustrup's book *The C++ Language*, together with extensive descriptions of how Release 2.0 differs from the definitions in the book, and full installation and operating instructions. Introductory price, \$499.

HCR Corp, 130 Bloor St W, 10th floor, Toronto, Ontario, Canada M5S 1N5. Phone (416) 922-1937. FAX 416-922-8397.

Circle No 385

TRANSLATOR

- Translates Modula-2 source code to C source code
- Runs on PCs or VAX computers

The M2CC/C translator package consists of three programs and a standard library in the form of definition and object modules. The first program, M2CC, is a single-pass

compiler that accepts Modula-2 source code and translates it into processor-independent intermediate code. You can optionally request a list file with integrated error messages. The Modula-2 language definition of M2CC is based on the third, revised edition of Niklaus Wirth's book *Programming*

U S E R R A T E D



E X C E L L E N C E

Feed this to your PC and it'll think it's an HP BASIC workstation.



Finally, there's a way for serious technical computer users to get the power and features of HP BASIC on a PC. The answer is HTBasic, a real engineering BASIC that turns your PC into an HP 9000 series 200/300 BASIC workstation—at a fraction of the cost.

Like HP's Rocky Mountain BASIC, HTBasic from TransEra is a state-of-the-art BASIC that gives you all the capabilities you need for complex engineering applications. Plus, you get important advanced features you won't find with any other PC BASIC. Like the complete set of HP graphic commands. Integrated HPIB (GPIB) syntax for intelligent instrument control. The advanced I/O Path system. And built-in matrix math. In fact, all the optional HP binaries are built in. There's nothing else to load. You even get the full screen program editing and debugging environment.

Discover the new solution for cost-effective technical workstations. HTBasic from TransEra.

HTBasic

HP, HP BASIC and HPIB are registered trademarks of Hewlett-Packard.

**DISCOVER
HTBASIC
FOR
YOURSELF**

Call today at
(801) 224-6550
or FAX us at
(801) 224-0355

TransEra

3707 North Canyon Road, Provo, Utah 84604 • TEL: 801-224-6550 • FAX: 801-224-0355

CIRCLE NO 144

in *Modula-2* (Springer Verlag, Berlin and New York, NY). The second program, M2C, processes the intermediate code and generates a C source file that you can compile to object code using any ANSI-C compiler. M2C processes the intermediate code procedure by procedure and module by module; the output

is well structured, and you can integrate standard C libraries into the translated program. The third program, Mak, analyzes a Modula-2 program that consists of multiple compilation units and generates from the program a *make* description file. You can use this description file with the Unix *make* utility

to automatically create a consistent program version. PC-DOS version, SFr 1500; VAX/VMS version, SFr 5000.

Glance Ltd, Gewerbestrasse 4, CH-8162 Steinmaur, Switzerland. Phone 01/853-39-49. FAX 01/853-08-09.

Circle No 386

Quality Protection for Advanced Technology

Skydyne's Standard Case Lines



Standard Fiberglass Cases—Excellent commercial/shipping containers. Can be modified to meet mil-specs or other specific requirements. 34 sizes to choose from.



Aluminum Sandwich Cases—Skydyne can make any size case, using a unique aluminum sandwich construction, without expensive tooling.



Standard ABS Cases—Excellent commercial/shipping containers. Combines high strength with light weight. 33 sizes available.

Since 1938, Skydyne has met the growing need for durable, lightweight, reusable equipment packaging through its many lines of standard cases. Such cases enable users to easily adapt their display or test equipment to transportable field use. All provide maximum protection against shock, vibration, and hazardous environments encountered during handling and transit. Most are available from stock for immediate shipment.

Custom options and modifications can also be specified for these cases. Contact factory with your requirements.

Call Toll-Free: 800-428-CASE

SKYDYNE

QUALITY PROTECTION FOR ADVANCED TECHNOLOGY



RIVER ROAD • PORT JERVIS, NEW YORK 12771 • 914-856-6655

METACOMPILER

- Runs on IBM PCs, PS/2s, and compatibles
- Compiles Forth code to machine code for Harris RTX-2000 μ C

The LMI Forth Metacompiler is a cross-compiler that runs on IBM PCs, PS/2s, and compatibles. The compiler generates native code for the Harris RTX-2000 μ C, whose instruction set maps so closely onto essential Forth-language elements that there is no need for an assembler. The metacompiler is a multi-pass, table-driven translator that allows local labels and conditional compilation directives. It lets you define and invoke new defining words and immediate words in the target code; optionally generates "headerless" code to conserve memory in the target system; and can generate both ROM-resident and RAM-resident code. The metacompiler can even create a new interactive Forth interpreter/compiler that will run on the target system. To run the metacompiler, you'll need a PC, PS/2, or compatible that has at least 320k bytes of RAM and 400k bytes of free hard-disk space, and runs PC-DOS 2.0 or later. You can order it either on two 5 $\frac{1}{4}$ -in. disks or one 3 $\frac{1}{2}$ -in. microdisk. Other versions of the metacompiler are available for a variety of 8-, 16-, and 32-bit processors from Intel, Motorola, and TI. \$750.

Laboratory Microsystems Inc, Box 10430, Marina del Rey, CA 90925. Phone (213) 306-7412. FAX 213-301-0761.

Circle No 387

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

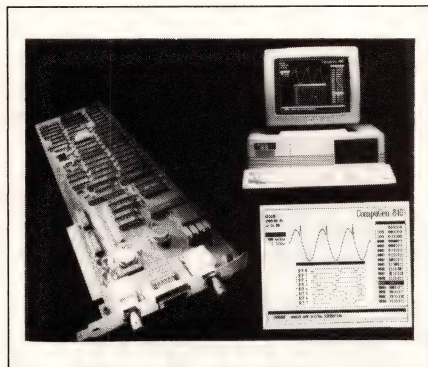
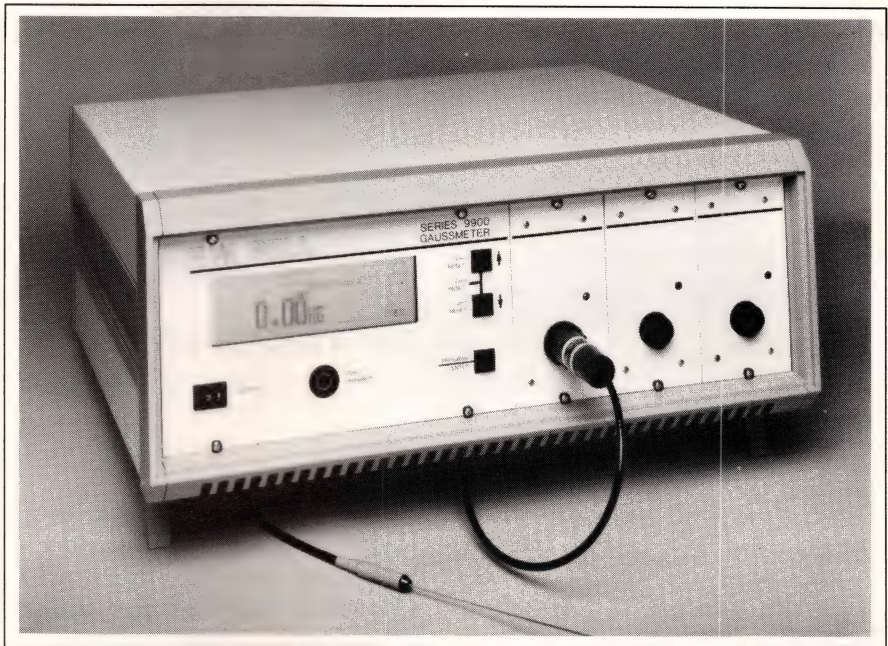
GAUSSMETERS

- Measure 3 to 3M Gauss from dc to 50 kHz
- Present data on 4½-digit back-lit LCD

Gaussmeters in the 9900 Series measure magnetic fields from 3 to 3M Gauss from dc to 50 kHz. The μ P-based units, which include both IEEE-488 and RS-232C interfaces, offer a menu-driven user interface and display their results on a 4½-digit back-lit LCD. The vendor offers a full line of probes for the meters. Single-channel unit, \$3800. Delivery four to six weeks ARO.

FW Bell Inc, 6120 Hanging Moss Rd, Orlando, FL 32807. Phone (407) 678-6900. FAX 407-677-5765.

Circle No 388



WAVEFORM GENERATOR

- Plugs into IBM PC bus
- Outputs analog data at 40M points/sec

The Compugen 840 arbitrary-waveform generator plugs into the IBM PC bus. It can generate analog waveforms with 8- or 12-bit resolution. Maximum data rate is 40M points/sec. While generating waveforms with 8-bit resolution, the board can simultaneously produce 8-bit-wide TTL patterns, but such operation restricts the data rate to 20M points/sec (equivalent to 10M 2-state patterns/sec). By sacrificing the waveform-generation capability, you can obtain 16-bit-wide digital patterns or obtain 20M 8-bit-wide patterns/sec. Maximum wave-

form depth is 16,000 points; maximum digital-pattern depth is 8,000 patterns. The board includes a crystal-controlled timebase, and has trigger capabilities that allow it to produce waveform bursts. The gain of the analog output amplifier is software programmable. \$2495.

Gage Applied Sciences Inc, 5905 Saint François Rd, Montreal, Quebec, Canada H4S 1B6. Phone (514) 337-6893. FAX 514-337-8411.

Circle No 389

BOARD-TEST SOFTWARE

- Adds ability to perform mixed-signal testing
- Allows calls to externally compiled programs

The latest release of software for the vendor's PC-based, 1800 Series of low-cost pc-board testers provides multicolor displays and adds the ability to test mixed signal (analog/digital) boards. The software also allows you to compile programs separately and call them from within a test program. This capability, which permits passing of parameters to the called program, simplifies the use of external instru-

mentation in test programs. Another added feature is variable timeout of back-drive tests of digital ICs. This feature allows users to safeguard parts that otherwise might be damaged when a back-drive condition is prolonged by the occurrence of a fault. A programmable short-circuit-detection threshold allows the use of the tester for inspection of bare pc boards. \$1500; testers, \$52,250 to \$167,160.

Teradyne Inc, 2625 Shadelands Dr, Walnut Creek, CA 94598. Phone (415) 932-6900.

Circle No 390

VOLTAGE STANDARD

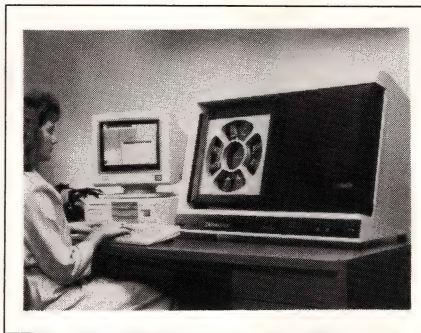
- Has output stable to better than 1 ppm/year
- Includes remote-sensing buffer, which can drive 15 mA

The 4910 is a solid-state voltage reference whose drift of less than 1 ppm/year rivals that of saturated standard cells. The unit incorporates four 10V "cells," each with its own independent power supply, heater, and temperature-control circuits. Because the elements are independent, errors attributable to

them are uncorrelated and are therefore detectable. The hardware can average the outputs of any combination of the cells to yield an improvement in long-term stability and short-term noise. Each cell incorporates a pulse-width-modulated amplifier, which is inherently stable with both time and temperature. An amplifier with remote sensing and 15-mA drive capability drives the 10V output, making the unit useful without external buffering for calibration of Kelvin-Varley dividers. When you remove ac power, internal batteries continue to supply the reference zener diodes for seven days. For longer periods away from ac sources, the unit accepts 10 to 40V dc standby power. \$8995. Delivery, 20 weeks ARO.

Wavetek Corp., Datron Div, Box 85434, San Diego, CA 92138. Phone (619) 450-9971. FAX 619-450-0325.

Circle No 391



ESD TESTER FOR ICs

- Can test eight 256-pin devices at once
- Applies impulses to 8 kV in 50V steps

The Zapmaster automatic tester verifies the ability of semiconductor devices to withstand ESD pulses whose amplitude is as high as 8 kV. The unit can accommodate eight devices at once, and each device can have as many as 256 pins. The system, which is based on a Compaq 386 computer and runs under the

control of MS-Windows-based software, performs V/I curve-trace measurements in 10-nA increments. You can vary the impulse amplitude in 50V steps and set the current rise time from less than 1 to more than 10 nsec. For testing in accordance with MIL-STD-883C, the unit produces a human-body-model waveform with a 5-nsec rise time. \$55,480.

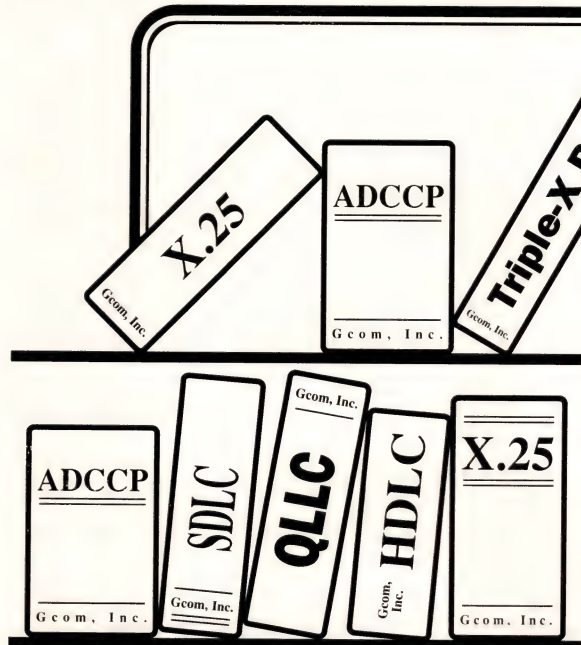
Keytek Instrument Corp., 260 Fordham Rd, Wilmington, MA 01887. Phone (508) 658-0880. FAX 508-657-4803.

Circle No 392

POWER ANALYZER

- Measures V, I, crest factor, power factor, real, and apparent power
- Handles 700V, 1000A, and 20 kHz

The PM1000 precision power analyzer measures the rms value and



Off the shelf protocol software.

Save time, save money with off-the-shelf protocol software from Gcom. We've been helping OEMs get their datacom products to market on schedule since 1980.

All our software is written in C to be hardware and operating system independent. Full source code is provided, and porting assistance is available.

With Gcom software handling protocol functions, you're free to concentrate on the parts of your project that can't be found on any shelf. For complete information, call Gcom today.

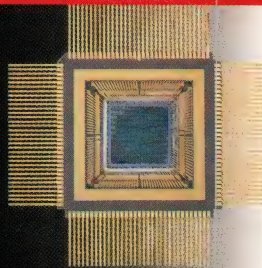
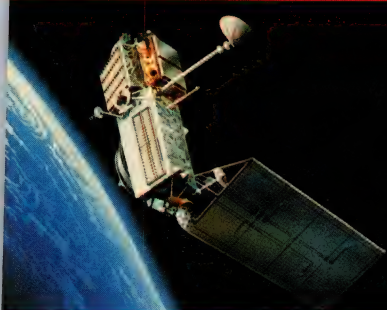
Specialists in
Computer Communications



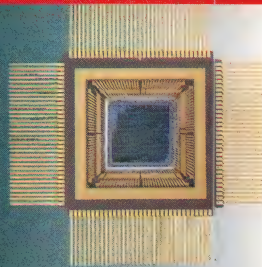
Gcom, Inc.
41 East University Avenue
Champaign, Illinois 61820
Phone (217) 352-4266
Telex 910-240-1477
FAX (217) 352-2215

CIRCLE NO 147

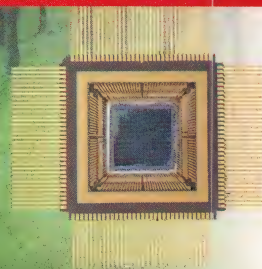
10⁷



10⁶



10⁵



10⁴

UTMC RAD-HARD

One source. A spectrum of solutions.

We deliver a full spectrum of rad-hard solutions, with military-standard and semi-custom products at tactical and strategic levels. Every aspect of UTMC's DESC-certified manufacturing – from design through final screening – is focused on meeting rad-hard requirements. Using our production-proven process, our ASICs deliver the hardest rad-hard of any epi- or bulk-CMOS supplier, with specifications to 10^6 rads total dose (10^7 functional), 5×10^{14} neutrons/cm², SEU below 3.4×10^{-8} errors/bit-day, and dose rate immunity better than 10^9 rads/sec. And you can be confident that our rad-hard products will meet datasheet specs after irradiation – we guarantee it. Moreover, we offer JAN-QUAL Class B, MIL-STD-883C, SMDs, and Level S. Our CAE tools support your semicustom designs on popular workstations, while our HIGHLAND® Design System makes

first-pass success our standard. When your program goes into production, we deliver. And by specifying UTMC for tactical applications, you get guaranteed rad-hard solutions for a small premium over standard non-hardened parts. Plus you save the expense, risk and time of individual part qualification. So whether your program calls for kilorad or megarad-plus, call UTMC for information on our full spectrum.

1-800-MIL-UTMC

1575 Garden of the Gods Road
Colorado Springs, CO 80907

HIGHLAND is a registered trademark of
United Technologies Microelectronics Center.



FIRST IN HIGH-REL

10³

harmonic content of voltage and current waveforms. It displays the dc component and the content of odd harmonics through the thirteenth. The instrument also measures real power, apparent power (volt-amperes), power factor, voltage and current crest factors, instantaneous current, and fre-

quency. It handles voltages from 2 to 700V rms, currents from 20 mA to 20A (1000A with an optional current transformer) and frequencies from dc to 20 kHz. \$2475.

Voltech Inc., 200 Butterfield Dr., Ashland, MA 01721. Phone (508) 881-7329. FAX 508-879-8669.

Circle No 393



DIGITAL MULTIMETER

- Measures frequency and capacitance
- Checks diodes and LEDs; tests continuity

The Circuitmate DM27 is a handheld digital multimeter that offers many functions not found in most DMMs. Besides measuring voltage, current, and resistance, the meter measures frequency in five ranges from 2 kHz to 20 MHz and capacitance in five ranges from 2 nF to 20 μ F. The meter also audibly checks continuity, tests diodes and LEDs, and incorporates a 20-MHz TTL logic probe that detects 25-nsec-wide pulses. The 11-oz unit, which has a basic dc accuracy of 0.8%, includes test leads, a spare fuse, and a 9V battery. Accessories enable temperature, radio-frequency voltage, high-voltage, and clip-on current measurements. \$129.95.

Beckman Industrial Corp., 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3200. FAX 619-268-0172.

Circle No 394

Never Before, So small yet so powerful.

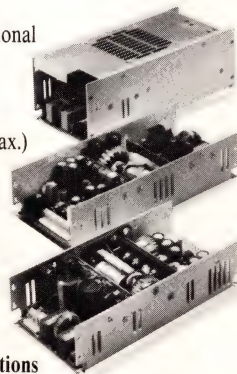
Xentek's New SX Series: The Smallest in the Industry

Xentek's new 100KHz Current Mode Power Supply line packs more power into less space than anyone in the industry. The SX130/150 Series has a packaging density of 2.34 Watts per cubic inch and its small size—2"×4"×8"—will let you fit 150 Watts of output power into only 64 cubic inches. And, our SX175/200 Watt through SX600 Watt product series are equally impressive.

Choose from 87 standard models in the SX Series which gives you more volt-amp combinations than anyone else. Or, we can tailor a unit to your requirements.

SX Series Standard Features:

- 4 Fully regulated outputs. Optional 5th output available.
- All outputs are independently adjustable.
- Low noise and ripple (0.3% Max.)
- On-board EMI filter.
- Power fail protection.
- Zero cross regulation.
- Minimum load required only on main channel.
- 2-year warranty.



Call Xentek for detailed specifications or to schedule a demonstration of the Small, Yet Powerful SX Series Power Supplies.

Xentek 
The Heart of Your System

760 Shadowridge Drive • Vista, CA 92083 • (619) 727-0940 • FAX: (619) 727-8926

© 1989 Xentek, Inc.

CIRCLE NO 149

WAVEFORM RECORDER

- Simultaneously captures 12-bit data on four channels
- Can take 200k samples/sec on each channel

The SRA 1204 waveform recorder uses a 12-bit A/D converter on each of its four channels. Each converter can take 200k samples/sec. The

Thanks to Elantec, ATE design engineers are no longer kept waiting on pins and needles.

With Elantec pin drivers and FET input buffers, the ATE industry can stop sitting on the edge of their seats.

Whether it's for IC or loaded PC board testers, our parts are higher performing than the competition. Not to mention more affordable.

As are Elantec analog ICs for all applications—from ATE, video and LANs, to instrumentation, disk drives, and more.

One product that pins down the fastest logic devices is our FET input EL2031 buffer amplifier. It drives $7000\text{V}/\mu\text{s}$ signals into 100 ohm loads. Or buffers those signals at the pin receiver.

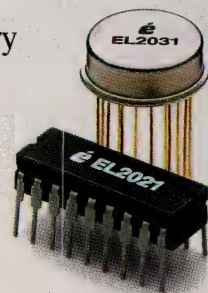
Another example is our EL2021 monolithic pin driver. It supports in-circuit and functional testing with a programmable slewrate to $250\text{V}/\mu\text{s}$.

Plus it drives externally programmed voltages into difficult and reactive loads and overdrives device outputs in the middle of loaded PC boards. Best of all, the EL2021 costs less, so you can afford a part per pin and eliminate multiplexing.

For all high-performance applications, look to the full family of Elantec high-speed analog products. Everything from amplifiers and buffers, to comparators and transistor arrays. Each backed by the industry's only two-for-one guarantee. Elantec, analog that's ahead of the times.

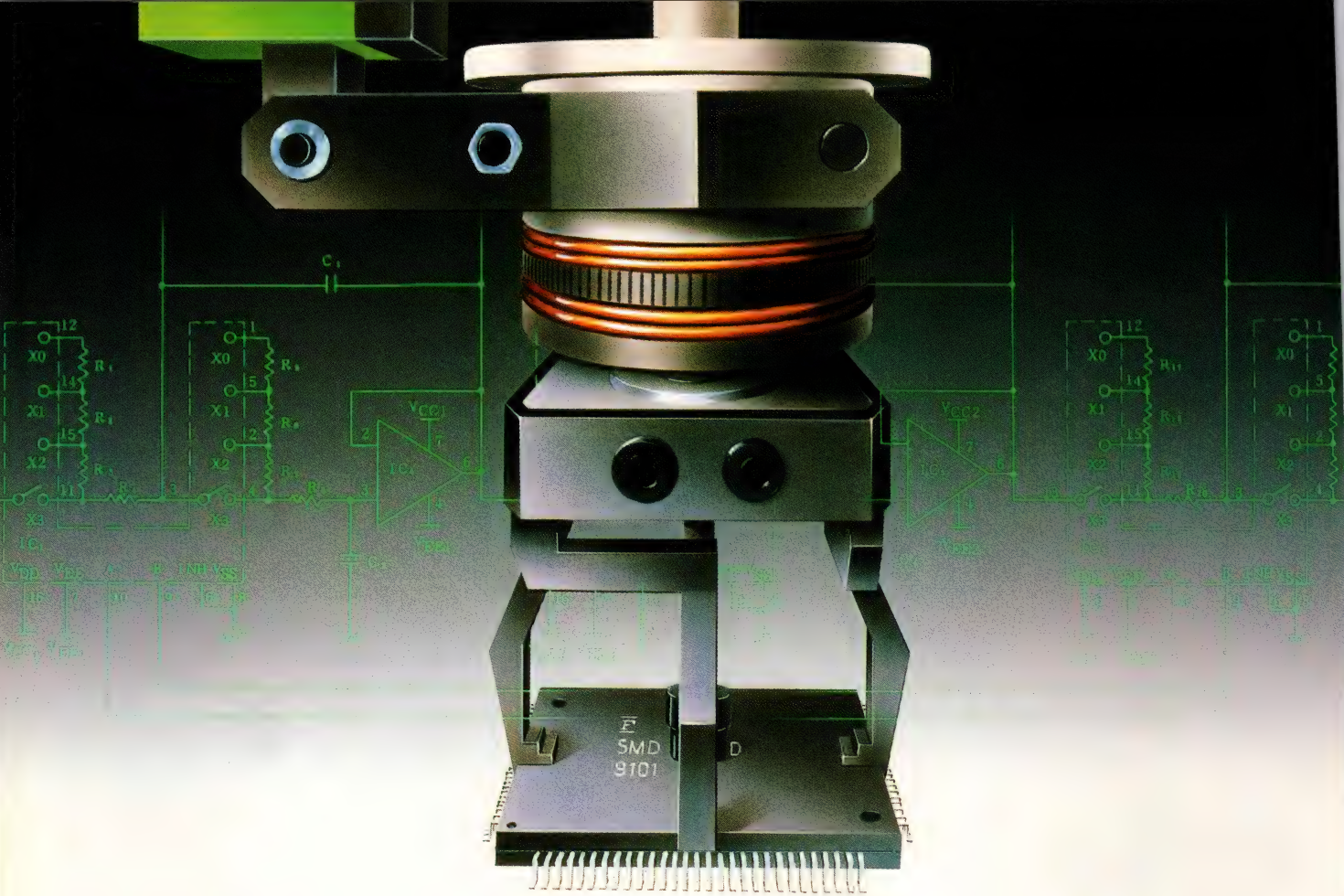
There's No Wait For A Selection Guide. For your free copy, circle the bingo number or write Elantec.

Because when it comes to designing PC board or IC testers, you'll never need to be needled again.



élantec
HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

Elantec: 1996 Tarob Court, Milpitas, CA 95035. Telephone: (408) 945-1323, Fax: (408) 945-9305 © 1989 Elantec
European Sales: 87 Jermyn Street, London, SW1Y6JD, England. Tel: 44-1-839-3841, Telex: 917835, Fax: 44-1-930-0751



You'll get faster, more precise assembly with Fujitsu SMT hybrid ICs.

Surface-mount technology (SMT) lets you design your products smaller. And produce them faster.

But the range of analog and analog/digital components — amplifiers, filters, comparators and regulators, for example — available in SMT packages has always been very limited. Until now.

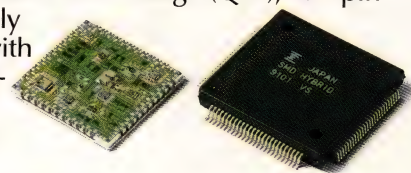
High capacitance, high resistance

Now you can get the analog, digital and analog/digital hybrid ICs with the specifications you want in the compact SMT formats you need — even circuits with capacitance up to $1\mu\text{F}$ — or resistance to $10\text{M}\Omega$.

And because they're Fujitsu hybrid ICs, you'll get something else as well: laser function trimming. We adjust the electrical resistance precisely, with power on, to ensure that each circuit function exactly meets your specifications.

Higher integration, smaller size

Our SMT hybrid ICs are not only precise and reliable, they're also smaller than ever before. Using barechip bonding and double-sided mounting, we've made our Quad Flat Package (QFP), 104-pin SMT hybrid ICs only half the height — with 4 times the integration — of our conventional DIP-type hybrid ICs.



So if you need hybrid ICs in an SMT format, the fastest way to find them is to pick up your telephone. Please call Fujitsu Mikroelektronik GmbH at 069-66320.

FUJITSU MIKROELEKTRONIK GmbH:

Lyoner Straße 44-48, Arabella Center 9, OG./A, D-6000 Frankfurt Niederrad 71, F.R. Germany Phone: 069-66320 Telex: 0411963 Fax: 069-6632122

FUJITSU COMPONENT OF AMERICA, INC.:

3330 Scott Blvd., Santa Clara, California 95054-3197, U.S.A. Phone: 408-562-1000 Telex: 910-338-0190 Fax: 408-727-0355

FUJITSU MICROELECTRONICS PACIFIC ASIA LIMITED:

805, Tsim Sha Tsui Centre, West Wing, 66 Mody Road, Kowloon, Hong Kong Phone: 3-7320100 Telex: 31959 FUJIS HX Fax: 3-7227984

FUJITSU LIMITED (Electronic Components International Sales Support Div.):

Furukawa Sogo Bldg., 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan Phone: National (03) 216-3211 International (Int'l Prefix) 81-3-216-3211 Telex: 2224361 Fax: (03) 215-1961

FUJITSU

unit, which plugs into the IBM PC bus, includes 64k or 256k words of storage for the sampled data. The board includes a multimode time-base, fast analog trigger, and programmable-gain amplifiers. The vendor bundles the units with a software package called Signal Graphics, which permits interactive control of the host computer and stores data in file formats compatible with third-party data-analysis packages. Also included are software drivers that permit you to create your own customized control software using high-level languages. \$2095.

Scientific Recording Assoc, 59 Princeton Terrace, Watertown, CT 06795. Phone (203) 274-7761.

Circle No 395

SIGNATURE ANALYZER

- Operates at clock rates to 20 MHz
- Offers 15-nsec setup time and 5-nsec hold time

The 20-MHz signature analyzer conforms to accepted signature standards and includes built-in setup routines, self-test routines, and diagnostics. The unit's setup time is 15 nsec; its hold time is 5 nsec. All inputs are fused, and both ac-powered and battery-powered versions are available. For operator training, you can use one unit to simulate fault signatures and a second to trace them. £385.

Flight Electronics, Ascupart St, Southampton SO1 1LU, UK. Phone (0703) 227721. FAX 070-333-0039.

Circle No 396

LOGIC ANALYZER

- Operates to 100 MHz
 - Costs under £900 for 32 channels
- The LA3200 is a 32-channel logic analyzer that operates to 100 MHz in synchronous mode and 25 MHz in asynchronous mode. A companion product, the LA4800, offers 48 channels and operates at the same speeds. Instead of CRTs, both units

incorporate 640×200-pixel, 9-in. LCDs with fluorescent backlighting; as a result, they are smaller and lighter than most instruments in their speed class. Multilevel triggering provides "If/Then/Else" sequencing and multiple-event or multiple clock-count delays. You can use all of the channels in trigger

qualification. The units provide a pair of nonvolatile reference memories and several setup memories. LA3200, £898; LA4800, £1195.

Thurlby Electronics Ltd, Burrell Rd, Saint Ives, Huntingdon, Cambs PE17 4LE, UK. Phone (0480) 63570.

Circle No 397

The PowerTech Advantage

...our unique ability to provide superior performance, timely delivery and competitive pricing on a variety of high-performance BiPolar Transistors, many of which can even be shipped from stock...plus applications personnel who provide prompt turnaround on your technical questions, price information and delivery status.

*Your First
2nd Source for
BiPolar Power
Transistors!*

(201)

791-5050

- TO-63 and TO-114 packages, as well as others.
- Manufactured under MIL-S-19500.
- Several QPL-approved power transistors.
- High SOAR, Low Vce (SAT), means better efficiency.
- Cross-referenced to Solitron, PPC, PTC, STC, SPE, Powerex and many more.
- For immediate replacement part number information and delivery call today!

PowerTech

"BIG IDEAS IN BIG POWER"

0-02 Fair Lawn Avenue • Fair Lawn, NJ 07410

201-791-5050 • FAX: 201-791-6805

Call or write today for our Design Guide Wall Chart.



120-MHz COUNTER

- *Costs less than \$700*
- *Optionally includes 1.3-GHz input*

The PM 6662 frequency counter performs reciprocal counting, an unusual capability for an instrument in the under-\$700 price class. As a result, the unit provides at

least seven digits of resolution with a 1-sec. measurement time, even at low frequencies. The basic instrument operates to 120 MHz and provides automatic trigger-level setting. An optional prescaled second channel extends the range to 1.3 GHz. Another option, which holds down the unit's cost, is a mathe-

matically temperature-compensated crystal-controlled timebase (MTCXO). Instead of using a proportional oven, the MTCXO operates the crystal at room temperature, senses that temperature, and mathematically corrects for systematic temperature effects. \$645.

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206. Phone (800) 443-5853, ext 77. TWX 910-445-2943.

Circle No 398

Philips Test and Measurement, Building HKF, 5600 MD Eindhoven, The Netherlands. Phone local office.

Circle No 399

Your Logic Analyzer Really Needs The PI-6500 Pattern Generator.

Here's Why:

1. The new Pulse Instruments PI-6500 Pattern Generator and your Logic Analyzer are a cost effective alternative to high-priced test systems.
2. Working together they offer you general-purpose digital signal send-receive capability.
3. You won't have to kluge digital signals or build special circuits any more—the PI-6500 Pattern Generator and your Logic Analyzer will do it for you.
4. You can now create interactive functions between the DUT, PI-6500 Pattern Generator and your Logic Analyzer.
5. You can make R&D or one of a kind test set-ups quickly and easily.
6. You can simplify digital test systems with this "off the shelf" Pattern Generator.
7. The PI-6500 Pattern Generator allows you to test at speeds up to 25 MHz.
8. You can compare actual and expected test results.
9. You can simulate any digital input signal complete with interactive control.
10. You can create complex serial and parallel digital data streams for any application.

The PI-6500 Pattern Generator features specs like: 16 to 112 Channels, 256 Trigger/Flag Combinations, Easy Programming, Serial/Parallel Modes. And it is ideally suited to large digital test systems and military applications.

Want more information?
Call Pulse today at:

(213) 515-5330.



Pulse Instruments PI-6500 Pattern Generator.

Pulse Instruments

1234 Francisco Street • Torrance, California 90502 • (213) 515-5330

WAVEFORM SAMPLERS

- *Eliminate power divider and associated losses*
- *Limit rms noise to 800 μ V max in 12.5-GHz bandwidth*

The SD20 is a single-channel, 20-GHz loop-through sampling head, and the SD22 is a 2-channel low-noise sampling head. Both units plug into the vendor's 11800 Series digital sampling oscilloscopes. The SD20, which features an acquisition rise time of 17.5 psec and typical noise of 1.3 mV rms, eliminates the need for a power divider in high-frequency measurements. Power dividers introduce losses that attenuate the observed signal. The SD22, whose typical rms noise is 400 to 500 μ V, and whose maximum rms noise is 800 μ V, has a 12.5-GHz bandwidth and an acquisition rise time of 28 psec. SD20, \$3250; SD22, \$3500.

Tektronix Inc, Box 1700, Beaverton, OR 97077. Phone (800) 835-9433, ext 170.

Circle No 400

You don't know what you've been missing

Until you've seen the new Nicolet 400 Series.



Imagine a memory that expands to 256K—and with four channels, one MegaSample. A unique, removable 44 Megabyte hard disk giving you *ten times* faster data recall and transfer. Time-saving PC interface. MS-DOS, disk downloadable sequences and programs you can customize. Unmatched calculation speed. Easy data archiving. Even four models offering your choice of speed and resolution.

That's the new Nicolet 400 Series. Power. Speed. Flexibility. Convenience. To see what you've been missing in *waveform acquisition*, call or write today.

Nicolet Test Instruments Division

5225-2 Verona Road, Madison, WI 53711, 608/273-5008 or 800/356-3090

Nicolet

INSTRUMENTS OF DISCOVERY

CIRCLE NO 154

LITERATURE

Catalog lists test instruments

The fall 1989 Heathkit Catalog describes several new models: one benchtop and two handheld and digital multimeters; two assembled oscilloscopes; a clamp meter; and an insulation tester. The publication also gives you information on how to purchase a multimeter.

Heath Co, Dept 350-045, Benton Harbor, MI 49022.

Circle No 401

Booklet features variety of instruments

The vendor's 20-pg instrumentation catalog presents more than 50 products. The publication describes handheld and bench calibrators, more than 20 process instruments, a full line of compact digital panel meters, and linear power supplies.



Product specifications, features, applications, and pricing and ordering information for every product, as well as illustrations, are included in the catalog.

Martel Electronics, Box 897, Windham, NH 03087.

Circle No 402

Presentation of sockets

A 20-pg catalog describes a variety of Textool sockets for test and burn-in applications. The booklet lists sockets for a variety of packages, including DIPs, SIPs, plastic leaded-chip carriers, and leadless ceramic chip carriers.

3M, Dept 89-54, Box 2963, Cedar Rapids, IA 52402.

Circle No 403

Handbook for PC data-acquisition products

The *PC I/O Guide Book*, a "how-to" catalog for PC data acquisition, test, measurement, and control, covers plug-in carrier boards and modules. It also includes a complete software library and guidance for configuring a cost-effective data-acquisition system for IBM PCs, PC/XTs, PC/ATs, and compatible com-

Military Germanium Diodes 1N270

JAN, JANTX, JANTXV

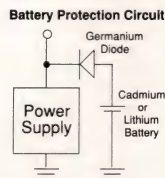
Another major contribution to the military industry from BKC

The military 1N270, tested to Mil-S-19500/200B (6/9/89), is ideal for Schottky replacement in such applications as: CMOS Circuit Protection, Battery Protection, Switching, Mixing, Frequency Discriminating, Gating, Detecting, and Log or A-D Converting.

More Military Hi-Rel Germanium Diodes are in the works, so keep watching... or call us for more information. We're BKC—manufacturers of quality products at competitive prices.

FEATURES

Lower forward voltage drop
Not ESD sensitive
Low Noise



The military 1N270 diode is the perfect replacement for Schottky 1N5711

Clean signal transfer
Soft forward turn-on
Operates at less than 5 μ A

BKC BKC International Electronics Inc.

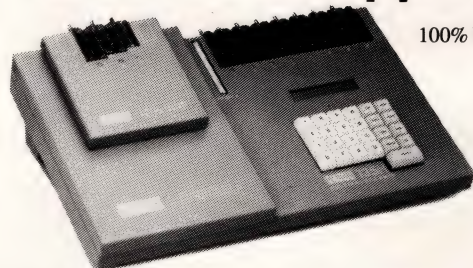
6 Lake Street
Lawrence, MA
USA 01841

Phone (508) 681-0392 • Fax (508) 681-9135

BYTEK 135H

Universal MultiProgrammer™

DATA I/O 288* Performance PLUS PLD Support !!



100% USA Made.

Model Shown:
135H-U
with optional
LOGICel.

- ★ Model 135H is a GANG & SET (E) EPROM Programmer.
- ★ Programs virtually all EPROMs & EEPROMs up to 2048K.
- ★ Universal support includes Bipolar PROMs & EPROM Emulation.
- ★ GANG Options for 40-pin MICROS & 40-pin EPROMs !!
- ★ Stand-alone or Computer Remote Control operation.
- ★ 12 Month WARRANTY & 12 Month FREE Field Device Updates.
- ★ Supports OrCAD™'s new PLD Tools Software.

BYTEK

1-800-523-1565

In Florida: (407) 994-3520

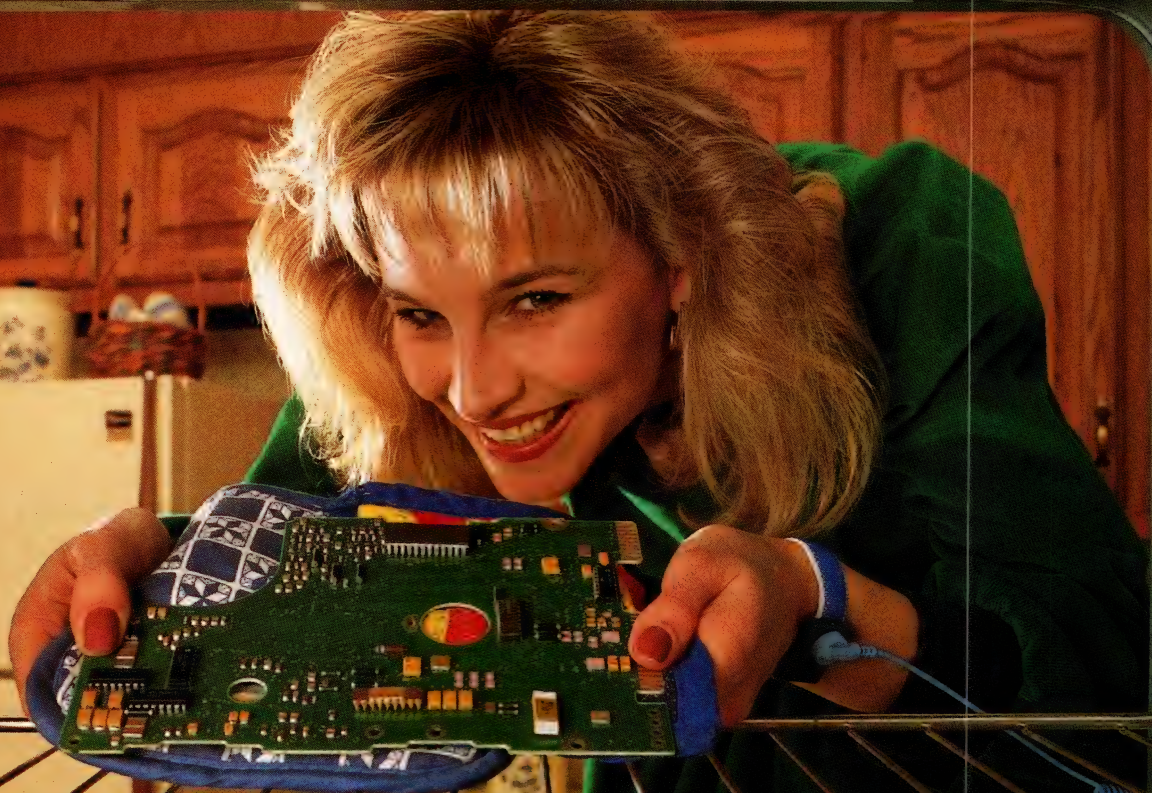
BYTEK Corporation • 508 N.W. 77th St, Boca Raton, FL 33487

FAX: (407) 994-3615 • Telex: 4998369 BYTEK

* DATA I/O is a registered trademark of DATA I/O Corporation.

CIRCLE NO 156

In Ceramic Chips, If You Can't Stand The Heat, Get Out Of The Kitchen.



New KEMET Ceramic Chips: More Protection From Thermal Cracking.

To give thermal cracking the cold shoulder, get acquainted with KEMET's new crack-resistant ceramic chips.

Years In The Making: It took nearly two years of dedication — modifying basic materials using new analysis tools, adapting different test and process techniques — but we developed a ceramic dielectric that won't wilt under thermal stress.

Dramatic Success: We board-tested more than a million of our new 1206-size chips at 260°C with no preheating. Result: dramatically improved survival rates, compared to three other suppliers' chips under the same conditions.

Send for ceramic chip catalog and application notes on surface-mount technology.

Tell Me More, KEMET

Send me application notes on

- | | |
|--|--|
| <input type="checkbox"/> Wave soldering | <input type="checkbox"/> Surface mount repair |
| <input type="checkbox"/> Reflow soldering | <input type="checkbox"/> Send me your ceramic chip catalog |
| <input type="checkbox"/> Mounting pad issues | <input type="checkbox"/> Call me for a consultation |

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

PHONE _____

EDN081789



KEMET®
Electronics Corporation
P.O. Box 5928
Greenville, SC 29606

HEADQUARTERS: Phone: (803) 963-6300, FAX: (803) 963-6521; U.S.A., Newport Beach, CA, Phone: (714) 640-9320, FAX: (714) 720-9807; Santa Clara, CA, Phone: (408) 986-0424, FAX: (408) 986-1442; Irving, TX, Phone: (214) 556-0009, FAX: (214) 401-0254; Schaumburg, IL, Phone: (312) 517-1030, FAX: (312) 517-1037; Stoneham, MA, Phone: (617) 279-0400, FAX: (617) 279-0406; Greenville, SC, Phone: (803) 242-5789, FAX: (803) 242-5795; EUROPE, Switzerland, Phone: 41-22-39-65-00, FAX: 41-22-39-65-00; Germany, Phone: 49-89-46-30-01, FAX: 49-89-46-04-117; France, Phone: 33-1-46-87-70-95, FAX: 33-1-49-78-06-63; United Kingdom, Phone: 44-279-757-343, FAX: 44-279-757-188; ASIA, Hong Kong, Phone: 852-3-770-5633, FAX: 852-3-770-5656; Singapore, Phone: 65-567-7677, FAX: 65-567-1585; Taiwan ROC, Phone: 886-2-752-8585, FAX: 886-2-721-3129; Korea, Phone: 82-02-599-8131, FAX: 82-02-533-8089.

puters; PS/2 model 30; and 386-type computers. The book features the IQ Workstation, the PC Expander, and SuperBoards, as well as the company's line of digital signaling packages.

Intelligent I/O, 1141 W Grant Rd, MS 131, Tucson, AZ 85705.

Circle No 404

RAM-DAC ICs and their uses

Three application notes on video RAM-DAC ICs include waveforms, diagrams, and tables illustrating the use of these DACs. *Video Formats and Required Load Terminations* describes and compares some of the more common standards, and

deals with the required load terminations for these DACs. *Improved PCB Layouts for Video RAM-DACs Can Use Either PLCC or DIP Package Types* highlights pc-board layout schemes for the video RAM-DAC portion of an IBM VGA-compatible graphics board. Finally, *Changing Your VGA Design from a 171/176 to an ADV471* explains how an ADV471 is used in a VGA graphics system.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021.

Circle No 405



When your specs call for emission control, call for Emcor's EMI/RFI series

Emcor offers a choice of shielding solutions, all of which are tested to MIL STD 285. These enclosures combine high strength with modular options and attractive esthetics. Emcor's commercial EMI/RFI enclosures are fabricated from 14-gauge cold-rolled steel and are fully zinc-plated. Our Tempest-style enclosures provide even higher levels of attenuation. They are fabricated from 12-gauge cold-rolled steel, nickel-plated and feature a unique latching system and door design (patent pending).

Contact Emcor to discuss your EMI/RFI needs. Our engineering staff has the knowledge and experience to help solve shielding problems. We can also design modified and custom products.



Crenlo, Inc.

1600 - 4th Ave. N.W.
Rochester, MN 55901
Phone 507-289-3371
FAX #507-287-3405

Manual sums up VMEbus testing

The *CVMEBS1 User Manual* provides the information needed by VME systems designers and integrators to make full use of the CVMEBS1 bus simulator. The publication is divided into six sections, including general information; a hardware-installation guide and operating manual; listings of arbitration and interrupt problems; and a section called "Hints and Kinks," which provides supplementary information for troubleshooting VME systems.

C&C Technology Inc, Bldg 9, Unit 60, 245 W Roosevelt Rd, West Chicago, IL 60185.

Circle No 406

Guide to IEEE-488 products

This 10-pg brochure sums up a comprehensive line of IEEE-488 bus controllers, extenders, expanders, and auxiliary products. The booklet provides photos and product descriptions for more than 40 hardware and software items and accessories.


ICS Electronics Corp, 2185 Old Oakland Rd, San Jose, CA 95131.

Circle No 407

EMCOR

Emcor is listed under GSA contract #GS-07F-17241.

CIRCLE NO 158



"I'm not a writer who writes about engineering; I'm an engineer who writes."

Anne Swager, EDN Magazine Edition Associate Editor

Anne's been reading EDN since she became an electrical engineer. And as an engineer, she has always counted on EDN to keep her up to date on new products and technology in the electronic markets. "As an engineer, I found myself always focusing on one project. I read EDN to find out what was going on in other areas of electronic engineering. Becoming a technical editor gave me greater exposure to the entire spectrum of electronics."

Not too long ago, Anne saw an ad like this one and answered it. "When I saw EDN's ad, I sent in my resume. I never even considered working for another publication."

Anne doesn't see working at EDN as a career change. "As an engineer, I liked problem solving, hands-on work, and circuit design. As an EDN editor, I still keep in touch with all three engineering activities. . . I just approach them from different angles. This position lets me investigate trends and new technologies and then write about them. So, I'm not limiting my capabilities as an engineer; I'm expanding them. Before you can explain a concept to someone else, you must understand it yourself."

You too can be an engineer who writes for EDN. All you need are a BS in electrical engineering, at least two years of design experience and the ability to write clearly. Salaries are competitive with those paid to engineers.

If you're interested in a career with the world's most prestigious electronics publication, send your resume to Kathy Leonard, EDN Magazine Edition, 275 Washington Street, Newton, MA 02158-1630. Or reach EDN by phone at 617/558-4405.

EDN Magazine Edition
News Edition



Lighter, thinner, brighter.

The difference is dramatic. Because Toshiba's new single-layer M-ST LCD modules are 25% lighter and 15% thinner than double-layer panels. And their high-contrast and brightness make them easier to see.

The M-ST LCD module from Toshiba. Lightweight, thin, easy to see. A new industry standard in monochrome LCD performance. All in all, quite a feather in our cap.

- Two sizes available: 640 × 400 dots (TLX-1501-C3M) and 640 × 480 dots (TLX-1551A-C3M)

In Touch with Tomorrow
TOSHIBA

For further information:

Toshiba America Electronic Components, Inc., Chicago Office: One Parkway North, Suite 500, Deerfield, IL 60015-2547 Tel: 312-945-1500
Eastern Area Office: 25 Mail Road, 5th Floor, Burlington, MA 01803 Tel: 617-272-4352 Fax: 617-272-3089
North Western Office: 1220 Midas Way, Sunnyvale, CA 94086 Tel: 408-737-9844 Fax: 408-737-9905

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number
for additional information from manufacturers.



FREE 26 Page CATALOG with all styles and designs of matching instrument knobs illustrated.

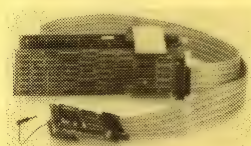
*Fax us your specs—we will
Fax you a quote...immediately!*

Buckeye
555 Marion Road
Columbus, OH 43207
Fax: 614/445-8224 Phone: 614/445-8433

CIRCLE NO 325

68HC11

PC-based emulator for 68HC11



- PC plug-in or RS-232 box.
- Pull-down menus with full window support, combined with command-driven User Interface.
- Up to 3.3MHz real time emulation.
- No intrusions to the 68HC11's resources.
- 48 bit wide 16K deep trace. All functions usable without disturbing emulation. Time stamping. Two level trigger.
- Symbolic and C Source Level Debugging, including in-line assembler and disassembler.

PRICES: 64K Emulator and pod \$2590,*
4K Trace \$1995*

CALL OR WRITE FOR FREE DEMO DISK!

NOHAU CORPORATION
51 E. Campbell Avenue
Campbell, CA 95008
FAX (408) 378-7869
(408) 866-1820

*US only

CIRCLE NO 326

PROM/PLD PROGRAMMER



**SPECIAL
OFFER!!
\$1295.00**

PROMPRO-8X Stand alone/Intelligent

Take advantage of this special offer valid only to
Oct. 1, 1989. Includes all supported devices to date.
Call today and ask for further details.

1-800-331-7766

**LOGICAL
DEVICES, INC.**

1201 N.W. 65th Place
Ft. Lauderdale, FL 33309
Tel: 305-491-7404
Fax: 305-491-6956

CIRCLE NO 327

**we make
innovation
work for you**



**Eaton toggle, rocker
and paddle switches.**
They take a bath.

These new "W" series switches withstand cleaning with pressure sprays, emersion or vapor. A special design seals out contaminants, including solder flux. Available in a wide variety of circuits, contact materials, ratings, terminations and actuators. Economical quantity pricing begins at \$1.76 for basic switch in 1,000-piece lots.

Eaton Corporation, Aerospace & Commercial Controls
Division, 4201 N. 27th St., Milwaukee, WI 53216.

EATON

CIRCLE NO 328

Don't Get Zapped!

High inrush current can **destroy** your sensitive VAX CPUs and peripherals in less time than it takes to flip a switch.

THE SOLUTION?

Power up with **Z-LINE TPC 115-10 MTD™**
the **smallest** power distribution
and control system available.

POWER UP WITH — — —

Z-LINE™



Our proprietary **Multiple Time Delay™** circuitry **sequences** your power-up to **protect** your systems from the spikes and surges, EMI & RFI, that **destroy** your hardware and **erase** your data. And our remote on/off and emergency shutdown **gives** the power control back to you.

All Pulizzi Engineering MTD™ controllers are
compatible with DEC and UPS systems.


PRICES FROM \$436 TO \$305

DON'T WAIT UNTIL IT HAPPENS, CALL TODAY!

PULIZZI ENGINEERING INC.
3260 S. Susan Street, Santa Ana, CA 92704-6865
(714) 540-4229 FAX (714) 641-9062

CIRCLE NO 329

**FREE
Literature**



**New! ESD and
Clean Room Packaging!**

Call BayStat today for data sheets on:

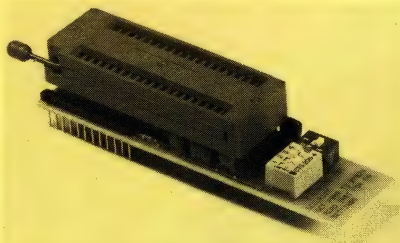
- Pink Anti-Static Bags
- ENA™ Amine-Free, Anti-Static Bags
- Black Conductive Bags
- Alpha Grid™ Conductive Bags
- Strato Grey™ Static Shielding Bags
- Type I Barrier Bags
- Class 100 Clean Room Bags

Over 300 stock sizes available. Custom bags manufactured to your specifications.

BayStat **415/364-3205**
3575 Haven Avenue
Menlo Park, CA 94025

CIRCLE NO 330

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



87C51 PROGRAMMER \$125.

Logical Systems brings you support for the Intel 87C51. The UPA87C51 programs this popular microcontroller on general purpose programmers that support the 2732A. With the UPA87C51 you can program the 8751 and 87C51 security bits and the 87C51 encryption array. Logical Systems, helping you get the most out of your programming equipment with our growing line of adapters. OEM inquiries welcome.

ADAPTER	PROGRAMS	PRICE
UPA8751	C8751, 8751H, AMD8753H, 8744	\$95.00
UPA87C51	C8751, 8751H, AMD8753H, 8744, 87C51FA	125.00
UPA8701V	Hitachi HD63701V	65.00
UPA451N	Signetics SC87C451 (64 pin DIP)	125.00
UPA63701X	Hitachi HD63701X (64 pin shrink dip)	
	-L Low insertion force socket	95.00
	-Z Textool ZIF socket	149.00
UPA63701Y	Hitachi HD63701Y (64 pin shrink dip)	
	-L Low insertion force socket	95.00
	-Z Textool ZIF socket	149.00
UPA63705V	Hitachi HD63705V	65.00

CALL (315) 478-0722 or FAX (315) 475-8460

LOGICAL SYSTEMS CORPORATION
P.O. Box 6184, Syracuse NY 13217-6184 USA, T.X. 6715617 LOGS

CIRCLE NO 331

Modular I/O board

Single-slot Qua Tech PXB-721 for PC-AT has 72 digital I/O lines. Connect three choices of data acquisition modules. Supports Labtech Notebook.™

For order info, call:
1-800-553-1170

QUA TECH

QUA TECH, INC.
478 E. Exchange Street
Akron, OH 44304

Labtech Notebook is a trademark of Laboratories Technologies Corp.

CIRCLE NO 332

100% STD-AT COMPATIBLE



The STD-AT from WinSystems is the first 100% AT compatible computer system on the STD-Bus. The 80286 CPU will operate up to 20MHz and supports the Phoenix BIOS. Designed for industrial applications, it requires little space and provides compact, rugged packaging. A wide range of industrial I/O is offered including networking, disk storage, video graphics, A/D, D/A, digital I/O, serial I/O, and more.

WinSystems, Inc.

P.O. Box 121361
Arlington, TX 76012
(817) 274-7553

CIRCLE NO 333

EXPRO-40 PC-Based Universal Device Programmer

\$495

PC-ADAPTER CARD

DTYPE 37 PINS CABLE

7 SOFTWARES AVAILABLE FOR POPULAR DEVICE PROGRAMMING

EPROM:NMOS or CMOS EPROM:2816, 17A, 64A, 256A...
BPMOM: From 32x 8 to 4096 x 8 Bipolar PROM MMI, NS, Signetics, TI, AMD, Motorola, Harris, Cypress MPU 8748: 8748, 48H, 49H, 41A, 42H, 41AH, 42AH, 48AH, 49AH
MPU 8751:8751H, 52H, 44H, 51BH, 52BH, C51, C252
PAL, EPLD, GAL, CMOS PAL: MMI, NS, TI, AMD, Cypress, Lattice, 16R8, 20V8, 20L10, 22V10, 22G10, 16V8, 20V8.

Software update possible for new devices.

Songtech International, Inc.
44061 So. Grimmer Blvd., Fremont, CA 94538
Tel: (415) 770-9051 Fax: (415) 770-9060

CIRCLE NO 334

Surface Mount Chip Component Prototyping Kits—Only \$49.95



CC-1 Capacitor Kit contains 365 pieces, 5 ea. of every 10% value from 1pf to .33µf. CR-1 Resistor Kit contains 1540 pieces; 10 ea. of every 5% value from 10Ω to 10 megΩ. Sizes are 0805 and 1206. Each kit is ONLY \$49.95 and available for Immediate One Day Delivery!

Order by toll-free phone, FAX, or mail. We accept VISA, MC, AMEX, COD, or Pre-paid orders. Company P.O.'s accepted with approved credit. Call for free detailed brochure.

COMMUNICATIONS SPECIALISTS, INC.
426 West Taft Ave. • Orange, CA 92665-4296
Local (714) 998-3021 • FAX (714) 974-3420

Entire USA 1-800-854-0547

CIRCLE NO 335

48 CHANNEL 25 MHz LOGIC ANALYZER



\$1595.00 + POD PRICE

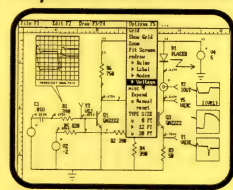
- 48 Chnnls @25MHz x 4K word deep/12 Chnnls @100MHz
- 16 Trigger words/16 Level Trigger Sequence
- Storage and recall of traces/setups to disk
- Disassemblers available for: 68000, 8086, 8088, 80286, 6801, 6811, Z80, 8085, 6502, 6809, 6303, 8031

NCI □ 6438 UNIVERSITY DRIVE,
HUNTSVILLE, AL 35806
(205) 837-6667

CIRCLE NO 336

Analog Circuit Simulation

IsSpice/286 Breaks the DOS Barrier



Run Unlimited Size Simulations on Your PC

IsSpice/286 \$210, a complete SPICE program that runs on 80286 based PC's in extended memory. Circuit size is

only limited by the amount of extended memory. Simulates over 700 components per megabyte of RAM. IsSpice/386 \$386, The fastest PC based SPICE program 1000 components per megabyte of extended RAM. IsSpice \$95, Runs on any PC - AC, DC, and Transient.

Special Graphics Turn Your PC into a Workstation

SpiceNet \$295, Schematic editor for any SPICE simulator. Generates a complete Spice netlist.

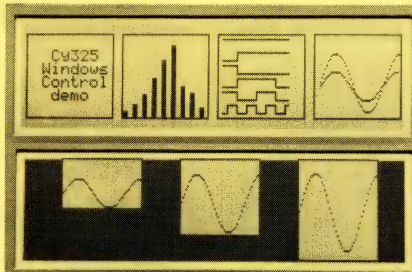
IntuSCOPE \$250, Graphics post processor that performs all the functions of a digital oscilloscope.

PreSPICE \$200, Extensive model libraries, Monte Carlo analysis and parameters sweeping.



P.O. Box 6607 (213) 833-0710
San Pedro, CA 30 Day Money
90734-6607 Back Guarantee

CIRCLE NO 337



LCD WINDOWS CONTROLLER

The CY325 supports LCDs up to 128x240 pixels (16x40 char) with easy-to-use high-level commands and Parallel or Serial interface to host computer. The 256 built-in windows (or make your own) support window-relative text, graphics, plotting, bargraphs, waveforms, scroll/wrap/clip, etc. Read from an A/D and Write into Window! Separate text and graphic planes can be written or erased in any window. Eight pins support a variety of functions (soft-keys, waveforms) or can be used for GP I/O. Icons or special fonts can be user defined. Giant character mode, etc. Save months of design time with the CY325. \$75 CMOS \$20/1000s.



Cybernetic Micro Systems Inc.

P.O. Box 3000 • San Gregorio, CA 94074 • USA
Phone: (415) 726-3000 Telex: 910-350-5842

CIRCLE NO 338

BIOS SOURCE CODE

The **The AT BiosKit** is a book with diskettes containing source code in C, plus utility programs to help you create a Bios. Now you can have a Bios with documentation for your own applications: modify boot-up, eliminate the keyboard, install security features, etc. Only \$199 complete. The **XT BiosKit** is only \$99, or get both BiosKits for \$279. The **Intel Wildcard Supplement** for the XT BiosKit is \$49.

— XT-AT HANDBOOK —

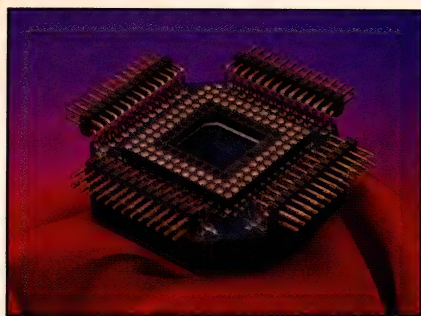
The **XT-AT Handbook** is full of hardware and software information in a shirt pocket size book. Over 70 pages covering 38 subjects, including connectors, I/O maps, controller programming, DOS and DEBUG commands, board dimensions, character codes, hard disk drive types, and much more. Only \$9.95 each qty 1-4, five or more, \$5 each.



Annabooks
12145 Alta Carmel Ct Suite 250-262
San Diego, California 92128
(619) 271-9526

CIRCLE NO 339

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



Full Line of PQFP Adapters

- At the prototyping stage, use a PQFP Adapt-A-Board™. Extends leads for easy wire wrapping.
- For emulation, use an Adapt-A-Pod™, like the one shown here for an 80386 PQFP package. Just plug and play.
- For production testing, a Bug Katcher™ turns your PQFP into an IC so you can start testing—ASAP.
- We stock all types of PQFP adapters. Quick turnaround on custom orders. Free catalog.

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664



CIRCLE NO 340

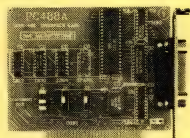
Free MSDOS & Mac Software Catalog for Electronic Engineers

AC/DC Circuit Analysis • Active and Passive Filter Design • Screen/Printer & Pen Plotter Graphics for Engineers • LaPlace Transfer Function/FFT Analysis • Logic Simulation • Root Locus Analysis • CAD/CAE • Digital and Analog Signal Processing • Curve Fitting • Statistics • Thermal Analysis • Math • Microstrip Design and Analysis • Data Acquisition • VISA & M/C Accepted

BV Engineering Professional Software

2023 Chicago Ave., Suite B-13 • Riverside, CA 92507
Tel: (714) 781-0252 • U.S.A. • TELEX: 6503089864

CIRCLE NO 343



LOW COST INTERFACE CARDS FOR PC/XT/AT

RS-485/422 Card [PC485] \$95-125

- Serial Async. Communication up to 4,000ft; 2 or 4 wires; NS16450 UART;
- COM1-4; Max. Baud Rate 56KB. High speed version (256KB) - \$165.
- Dual drivers/receivers; Handles 64 devices; Compatible with most comm. swt.
- DB9 or phonejack. Sample communication software available - \$50/150

IEEE-488 Card [PC488A] \$145

- Includes INSTALLABLE DOS DEVICE DRIVERS and support for BASIC.
- Additional Support for ASSEMBLY, C, Pascal and FORTRAN - \$45 (all)
- IRQ (1-6), DMA channel 1 or 2. Up to 4 boards per computer.
- Compatible with most IEEE-488 Software packages for IBM-PC (e.g. ASYSTANT-GPIB, Lotus Measure). Compatible with NI's GPIB-PC/AT.

IEEE-488 Card [PC488B] With Built-In Bus Analyzer \$345

- Software Support for BASIC, QuickBASIC and GWBASIC (PC488C only)
- Additional Libraries for C, Pascal, FORTRAN, Assembly available - \$45 (all)
- Powerful menu-driven BUS ANALYZER runs in the background while 488 programs or commands are executed. Features Program Stepping, Break points, real time bus data capture (4K buffer), instant screen toggling.
- Complete Controller / Talker / Listener capability. Based on TI's TMS-9914.
- NEC-7210 based card (compatible with National Instruments PC/AT).

A/D + D/A + DIO + Counter \$295-995

- 8/16 differential/single ended Input Channels; 12-14 bit Resolution; Conversion Speed 25-110K/sec; Input Range = 0.5V to +10V. Programmable gain.
- D/A: 1/2 channels, 12-14 bit Resolution; DIO: 16Out/16In; TTL compatible.
- Programmable Interval Counter/Timer; Uses Intel 8253/8254.

MC / VISA / AMEX

Call today for datasheets!



B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086
TEL: (408) 730-5511 FAX: (408) 730-5521

CIRCLE NO 346

Create a **DISKLESS PC**
IT's EASY..IT's SIMPLE.....
THERE's Nothing to it!!!

PROMDISK™ III IBM PC DISK EMULATOR CARD

- IBM PC/XT/AT Compatible
- Emulate up to 1.024Mbyte Drive
- Emulate 3 drives simultaneously
- 8 - 32pin JEDEC Standard Sockets
- Mix EPROMs, EEROMs, SRAMs
- Supports popular Byte-Wide chips
- On-Board BIOS ROM
- Occupies 32K PC address space
- Includes PROMDISK™ III Software

\$495 Each

For Information Call or Write:

MICRO COMPUTER SPECIALISTS, INC.
810-208 Los Vallecitos
San Marcos, CA 92069
(619) 744-8087

CIRCLE NO 341

C for the 8051 Compare:

Benchmark Results —Sample program:
Eratosthenese sieve Program from BYTE (1/83),
expanded with I/O and interrupt handling.

	Archimedes ICC51 v2.20A	MCC51 v1.2	FRANKLIN C51 v2.1
Compilation time	12 sec ✓	18 sec	17 sec
Linkage time	29 sec	9 sec	6 sec ✓
Execution time	11.45 sec	9.00 sec	0.88 sec ✓
Total code size	5318 bytes	3798	1726 ✓
Sieve module size	736	1021	541 ✓

Call now for your free DEMO disk.



FRANKLIN
SOFTWARE, INC.

888 Saratoga Ave. #2 • San Jose, CA 95129
(408) 296-8051 • FAX (408) 296-8061

CIRCLE NO 344



Free Catalog For Connector Specifiers

LEMO's Pocket Catalog permits connector specifiers to quickly determine which LEMO connectors meet their needs. Catalog includes tables that are organized around the main elements needed to specify connectors: number of contacts, working voltages, amps, collet ranges to accommodate cable OD, shell styles and insulating materials.

Connector families include mixed and multi contact connectors, environmentally sealed connectors, coaxial, triaxial, high voltage and plastic.

LEMO USA, INC.

PO Box 11488, Santa Rosa, CA 95406
Phone 707/578-8811, Telex 340-933, FAX 707/578-0869
800-444-LEMO(5366)

CIRCLE NO 347

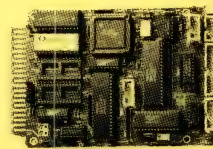
Free PC Software

INTELLIGENT ACQUISITION & CONTROL COMPUTER

The SBS-250 handles complex control and data acquisition problems with a single card. Its small size and ease of integration are ideal for embedded systems. Use your PC to develop the software. System includes CAMBASIC™, a fast, industrial compiler. Write your program and save it to on-card EPROM or EEPROM programmer. Programs autorun on powerup. CAMBASIC supports all the hardware features including interrupts:

- 4 analog input channels with 12-bit resolution
- keypad input
- real time clock
- networking option
- 32 parallel I/O lines
- 2 RS-232C serial ports
- sound and PWM outputs
- 9 counters and 8 timers

Drives Opto 22 module racks, 4.5" x 6.5". 5V only CMOS circuitry. Other models available. Call 303-430-1500 for complete catalog. Unit price is \$395.



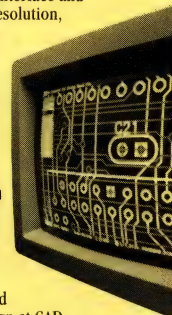
OCTAGON SYSTEMS CORPORATION
6510 W. 91st Ave.
Westminster, CO 80030

CIRCLE NO 342

"Best Value" in PCB Design

Tango™ sets the pace in PC-based circuit board design with an easy-to-use, pop-up menu interface and powerful features including 1 mil resolution, full SMT support, DRC, Gerber and PostScript™ output, fast high-completion autorouter, and photoplot previewing. Configure your personal PCB design station from our selection of entry-level and expert tools, starting at just \$595.

Tango™



See for yourself why engineers rated Tango the "Best Value" in PCB design at CAD Showdown '89. Rich functionality, one year's updates, free tech support and BBS, plus our 30-day guarantee. Call today.

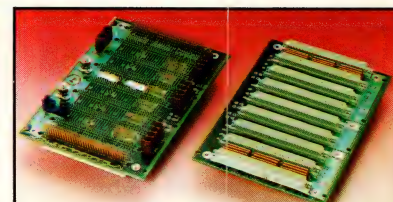


FREE EVALUATION PACKAGE

800 433-7801 619 554-1000 619 554-1019 Fax

ACCEL™ Technologies ■ 6825 Flanders Drive ■ San Diego, CA 92121 USA
International prices may vary. Contact us for the distributor nearest you.

CIRCLE NO 345



OVER 500 VME products listed in our new catalog...

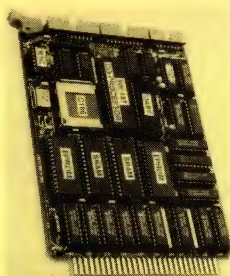
Backplanes, card cages, card cage/backplane assemblies, wire-wrappable boards, extender cards, and enclosures

Send for your free copy
See you at the BUSCON Show - Booth #601

Hybricon

12 Willow Road, Ayer, MA 01432
Factory (508) 772-5422

CIRCLE NO 348



16 MHz 80C186/C187 SINGLE BOARD COMPUTER

R.L.C. continues to offer the latest technology on the STD Bus. Our newest 16-bit Single Board Computer offers a CMOS 80C186 and new CMOS 80C187 Numeric Co-Processor. On-Board functions include MEMORY, SERIAL PORT, REAL TIME CLOCK, TIMERS, DMA, INTERRUPT CONTROLLER, RTC and RAM BATTERY BACKUP, WATCH-DOG TIMER and much more. Available in speeds up to 16 MHz. For more information and technical assistance please call Robert Coomer at

R.L.C. ENTERPRISES
4800 Templeton Road, Atascadero, CA 93422
(805) 466-9717

CIRCLE NO 349

EZ-WRITER™

(E)EPROM Multiprogrammer™

**DATA I/O 212* Performance
For Only \$995.**

100% USA
Made



- Supports (E)EPROMs up to 40-pins.
- Stand-alone or Remote.
- 40-pin Micros Opt.
- SET/GANG 4 (E)EPROMs Opt.
- Parallel port for Fast Up/Down Load.
- 256K bytes, expandable to 16 megabits.

BYTEK 1-800-523-1565
In Florida (407) 994-3520
Fax: (407) 994-3615

* DATA I/O is a registered trademark of DATA I/O Corporation

CIRCLE NO 752

2 parallel, 2 serial, 1 board

Qua Tech DSDP-402 for PC-AT has two parallel ports, and two serial ports for any combination of RS-232, 422, and 485 communication. All ports address selectable. Interrupts sharable and selectable.

For order info, call:
1-800-553-1170

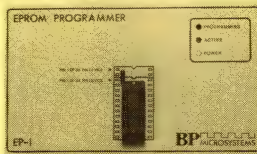
QUA TECH

QUA TECH, INC.
478 E. Exchange Street
Akron, OH 44304

CIRCLE NO 755

EPROM PROGRAMMER

- ✓ Programs 2764 in 8 sec, 27512 in 44 sec
- ✓ Reads, copies and programs over 475 E/EPROMs from 35 mfg's including 276-27513, 27011, 68764, 68766, 2804-28256
- ✓ Automatically uses the fastest recommended algorithm as specified on the manufacturer's data sheets to ensure reliable data storage
- ✓ Connects to RS-232 on any computer, PC, XT, AT, PS/2, Mac, etc.
- ✓ Supports XMODEM/XMODEM CRC protocols & ASCII file xfers
- ✓ Optional microcontroller heads support 874x and 87C51 series
- ✓ Supports Intel, Motorola, straight hex, hex-space & binary files
- ✓ Eng'r support team for fast updates ✓ Checksums supported
- ✓ One-year warranty (parts & labor) ✓ Gold Textool socket
- ✓ Toll-free technical support ✓ Collates 16- & 32-bit
- ✓ 30-day money back guarantee ✓ Same day shipment
- ✓ 8 baud rates to 38400 ✓ UV erasers from \$39.95
- ✓ Thousands of satisfied customers attest to the EP-1's great value
- ✓ Low price, \$349, includes IBM compatible communications program, user's manual and two free update coupons



The Engineer's Programmer

CALL TODAY 800/225-2102

BP MICROSYSTEMS

10681 Haddington, Suite 190, Houston, TX 77043
713/461-9430 FAX 713/461-7413

CIRCLE NO 350

IEEE-488

488 (GP-IB, HP-IB) control for your PC/XT/AT

Control instruments, plotters, and printers. Supports BASIC, C, FORTRAN, and Pascal. Fast and easy to use. High-speed DMA. Software library included so you spend less time programming.

Thousands sold. Risk free guarantee. Hardware and software - \$395.

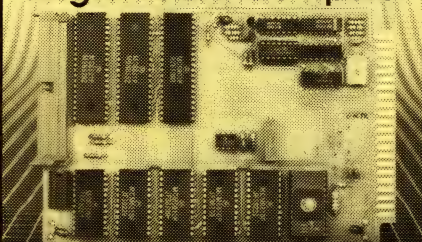
Product literature 1-800-234-4CEC
Technical assistance 617-273-1818

cec

Capital Equipment Corp.
Burlington, MA. 01803

CIRCLE NO 753

\$76.50* Single Board Computer



*500 piece price, model MCL45 (shown)

6800 MPU, serial I/O, parallel I/O, RAM, EPROM, 44-pin 4.5" x 6.5" PCB

EXPANSION MODULES: RAM, EPROM, CMOS RAM/battery, analog I/O, serial I/O, parallel I/O, counter/timer, IEEE-488, EPROM programmer, floppy disks, cassette, breadboard, keyboard/display.



WINTERK
Wintek Corp.
1801 South Street
Lafayette, IN 47904
317-742-8428
(800) 742-6809

CIRCLE NO 756

Quality switches with built-in dependable protection



Switch/Circuit breaker combination Single or Double Pole • Snap Action

High quality, long life, low cost combination unit saves you money by eliminating individual switch, circuit breaker or fuse and light.

You buy, stock, mount and wire only one component. High reliability of 25,000 cycles at rated load. Current ratings from 0.1A to 16A at 250 VAC. Both double and single pole units fit same small size panel cut out for single pole snap-in mounting. Variety of handle colors and styles.



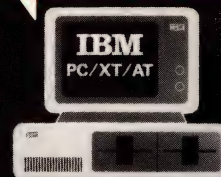
Call or write for catalog

E-T-A® CIRCUIT BREAKERS

7400 N. CRONAM ROAD, CHICAGO IL 60648 • (312) 647-8303

CIRCLE NO 751

MIL-STD-1553



**MIL-STD-1553 Interface Board
For IBM-PC/XT/AT or Compatibles**
Dual redundant bus controller, remote terminal and monitor with powerful easy-to-use software. **From only \$2095**

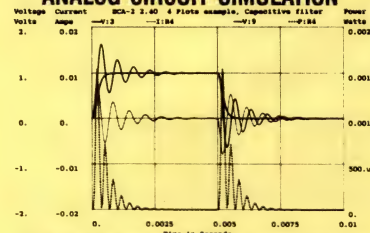
Call now for data on MIL-STD-1553 and ARINC 429 for PC/XT/AT, VME and VXI

Ballard Technology

1216 N.W. 75th St.,
Seattle, WA 98117
(206) 782-8704

CIRCLE NO 754

ANALOG CIRCUIT SIMULATION

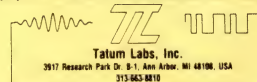


ECA-2: For design engineers who hate to waste their time and money. ECA-2 Electronic Circuit Analysis is a high performance, low cost, interactive analog circuit simulator. It reduces equipment expenses by eliminating the need for temperature chambers, signal generators, etc. Cuts weeks out of the design cycle time by simulating instead of prototyping. Available for a wide range of computers and operating systems.

- AC, DC, Transient
- Fourier, Temperature
- Worst-case, Monte Carlo
- Sine, Pulse, PWL, SFFM, and Exponential generators
- ECA-2 Offers:
 - Built-in real time graphics
 - Multiple plots
 - Interactive or batch
 - Online help
 - Full nonlinear simulator
- Frequently updated
- Over 500 nodes
- Money back guarantee
- SPICE compatible models
- 2 to 50 times faster than SPICE

ECA-2 2.40 IBM PC \$775

Turn-key Systems Available Call for more info and FREE DEMO disk



Tatum Labs, Inc.
2917 Research Park Dr. B-1, Ann Arbor, MI 48106, USA
313 963-8810

CIRCLE NO 757

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

✓ **DATA I/O PROGRAMMERS:
GREAT, H/W FLEXIBLE.**

✓ **SAILOR PROGRAMMERS:
GREAT, S/W FLEXIBLE.**

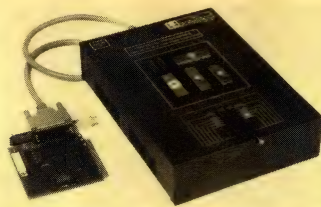
Find out why. Please call for a free demo disk.
Sailors support: ★ 7ns PALs ★ 12ns GALs
★ 2-MEG EPROMs ★ PROMs ★ EEPROMs
★ EP900 ★ EP1800 ★ 8751 and many more



**1-800-627-2456
FAX 408-736-2503
Advin Systems Inc.**

Data I/O: trade mark of Data I/O Corp. ★ Sailor: trade mark of Advin Systems Inc.

CIRCLE NO 758



**PC BASED UNIVERSAL
DEVICE PROGRAMMER \$595-895**

- Programs EE/EPROMs, PALs, GALs, IFLs, EPROMs, MICROs, BIPOLARS.
- Software driven pin drivers. D/A generated programming voltages.
- Upgradeable for virtually any future programmable devices up to 40 pins.
- Self-sustaining operation. No additional modules or plug-in adapters required.
- Includes user friendly MEMORY BUFFER FULL SCREEN EDITOR.
- Friendly Menu-Driven interface. Device selection by P/N and manufacturer.
- Supports 81632 bit word, Intelligent I & II, Quick Pulse programming.
- Functional testing. Register-Protocol, FUSMAP EDITOR for logic devices.
- File formats accepted: Intel Hex 86/88, Tetonix Hex, Motorola S, JEDEC.
- Customer support via voice line, dedicated BBS or fax. Full 1 year warranty.
- Base price includes Interface card, cable, Memory device library and 1 year free updates. Additional Device Libraries (Logic, Micros, Bipolars) \$95 ea.
- Libraries updates available every 6 mo. and can be received via floppy or BBS.

**PC BASED 8-SOCKET
GANG PROGRAMMER \$595**

- Handles all memory devices to 32 pins. (Upgradeable up to 8 megabit parts).
- FULL SCREEN BUFFER EDITOR plus all applicable features from above.
- Customer support via voice line, dedicated BBS or fax. Full 1 year warranty.
- Includes PC Interface card, Memory device library and 1 year free updates.

MC / VISA / AMEX

Call today for datasheets!



B&C MICROSYSTEMS INC.

355 WEST OLIVE AVE., SUNNYVALE, CA 94086
TEL: (408) 736-5511 FAX: (408) 736-5521

CIRCLE NO 759

**Z-1000B
UNIVERSAL
PROGRAMMER**



- PROGRAM THOUSANDS OF DIFFERENT DEVICES
- NO PERSONALITY MODULES REQUIRED
- DESIGNED FOR EASE OF OPERATION
- STAND ALONE AND MS-DOS DRIVEN
- SELF CALIBRATING
- QUICK FLIP LCC AND SMT ADAPTERS



SUNRISE ELECTRONICS, INC.

524 South Vermont Avenue, Glendora, California 91740
(818) 914-1926

CIRCLE NO 760

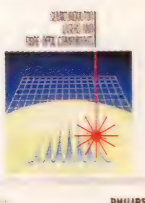
**RELIABILITY
PREDICTION
SOFTWARE**

ARE YOUR PRODUCTS RELIABLE?

The RelCalc 2 Software Package predicts the reliability of your system using the part stress procedure of MIL-HDBK-217E, and runs on the IBM PC and full compatibles. Say goodbye to tedious, time consuming, and error prone manual methods! RelCalc 2 is very easy to use, and features menu windows, library functions, global editing for what-if? trials, and clear report formats. Try our Demo Package for \$25.

T-CUBED SYSTEMS, 31220 La Baya Drive #110, Westlake Village, CA 91362. (818) 991-0057 • FAX: (818) 991-1281

CIRCLE NO 761



PHILIPS

Free Laser Brochure from Philips.

MOVPE technology offers your laser-based products unmatched reliability, wavelength flexibility and a choice of relevant optical parameters. Philips' latest range of MOVPE ternary lasers includes gain-guided and index-guided Self-Aligned Structure lasers, and Proton-Bombarded gain-guided lasers. Find out what Philips' MOVPE lasers can do for you. Send for our free brochure.

Philips Components, MC Dept. (Bldg. BA), P.O. Box 218, 5600 MD, Eindhoven, the Netherlands Telex 35000 phtc nl/nl je vmc



PHILIPS

CIRCLE NO 762

**BUY THE WORLD'S MOST
POPULAR PROGRAMMER FOR
ONLY \$159* A MONTH!**

If you are budget limited, but need the reliability of an industry-standard 29B Programming System, call today for information on Data I/O's leasing alternative through U.S. Instrument Rentals.

Call Data I/O at **1-800-247-5700, Ext. 534**

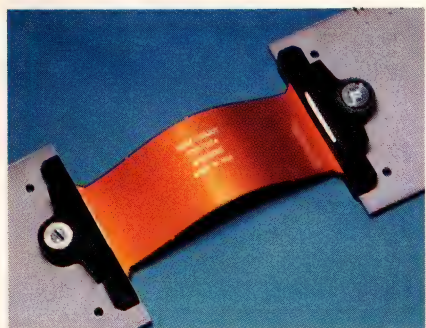
or U.S.I.R. at **1-800-USIR-123**

*Based on a \$5,565 system price with a 4-year lease-to-own.

DATA I/O
Corporation

CIRCLE NO 763

CONNECTION WITHOUT DETECTION



INVISICON® Controlled Impedance Connectors preserve transmission signal quality in very high speed/high density digital applications. Low dielectric constant flex circuit has contacts on 10-25 mil pitch. Standard 51-contact part available. **Rogers Corp.**, One Tech. Dr., Rogers, CT 06263 203/774-9605

CIRCLE NO 764

Redel Connectors



The Plastic Choice

REDEL Features:

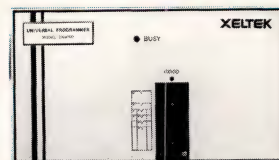
- Quick Connect-Disconnect Design
- Autoclaveable PSU Shell Material
- Lightweight and Compact
- Temperature & Corrosion Resistant
- Color Coding and Keying Exclusivity
- Variety of Shell Styles and Configurations
- 2-9 Solder or Printed Circuit Contacts
- Precision Designed and Engineered
- Cable Assemblies

Sold and distributed by

LEMO USA, INC. P.O. Box 11488, Santa Rosa, CA 95406
Phone (707) 578-8811 FAX (707) 578-0869 Telex 340-933
800-444-LEMO (5366) Please call for the rep nearest you.

CIRCLE NO 765

**UNIVERSAL
PROGRAMMER**



For E(E)PROM, PAL, BIPOLAR
8748/51 Series PROGRAMMING
& IC/Memory TESTING
High-Speed, Parallel Interface
ONLY \$545 COMPLETE
Also Individual/Gang Units

XELTEK

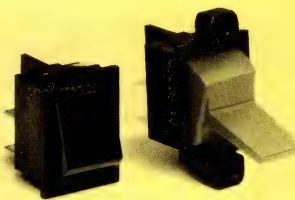
473 Sapena Ct. Unit 24
Santa Clara, CA 95054

1-800-541-1975 (Toll Free Order)
Tel: (408) 727-6995, Fax: (408) 727-6996
COD, VISA, MC, AM EX Accepted

CIRCLE NO 766

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

we make
innovation
work for you



Eaton new rocker switches. They're a snap.

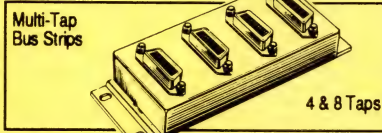
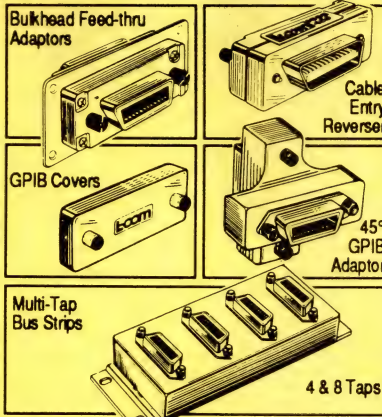
The new Series 8090 Intermediate Rocker Switches easily snap into industry standard 22mm x 30mm panel cut-out. Optional sub-panel mounting housing available. U.L. recognized, C.S.A. Certified, and VDE approved. Rocker or paddle actuators. Wide range of actuator and bezel colors. Quick connect terminals are .250" wide and tin-plated for easy soldering. Single or double-throw, single throw. Economically priced at \$0.91 in 1,000-piece lots.

Eaton Corporation, Aerospace & Commercial Controls Division, 4201 N. 27th St., Milwaukee, WI 53216.

EATON

CIRCLE NO 767

IEEE-488 USEFUL AIDS



DELUXE and MOLDED IEEE-488 Cables too!

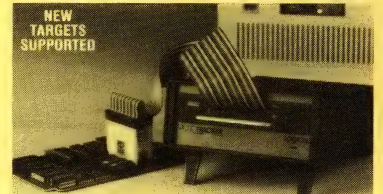
L-com

1755 Osgood St., N. Andover, MA 01845
Inquiries 508 682-6936 FAX 508 689-9484
Toll Free Ordering 800 343-1455

CIRCLE NO 768

MICROTRACKER™

Real-Time Software Analyzer/Debugger



The MicroTracker™ can significantly reduce the cost of your next real-time product development project. Advanced features speed software development and enhance quality assurance.

FEATURES

- 2K or 8K Trace Memory
- Interval Timer
- Performance Analysis
- RS-232 Interface
- IBM PC Software
- Symbolic Disassembly
- Low Cost from \$1295
- Instruction Disassembly for Z80, 8085, 6502, 6802, 6809, 8031/8051, 80188/80186, V40/V50
- Call for Free Brochure

LOGICAL
ADVANCES

52 W. HENDERSON RD.,
COLUMBUS, OHIO 43214
(614) 267-4405

CIRCLE NO 769

Quartz Crystals Oscillators

212-505-5340

- World's Smallest
- SMT & Thru-hole
- 10kHz-35 MHz
- Ceramic & Metal Pkgs
- Free Catalog

Micro Crystal Division/SMH

CIRCLE NO 770

Gridless, 100% Autorouting



Create and revise schematics and PCBs quickly and simply with **HiWIRE-Plus®** and your IBM PC. With the new, gridless, multi-layer autorouter (AR) for HiWIRE-Plus, creating printed-circuit layouts is even faster. AR and HiWIRE-Plus are each \$895 and come with thirty-day money-back guarantees. Credit cards are welcome.

Wintek Corporation

1801 South Street, Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 771

SPECIAL
OFFER

PHOTO PLOT

AUTOROUTE

SCHEMA PCB

PCB, PLOT & DRILL
Regularly \$2,025
until August 31st
all three = \$1,495.
You save \$530!

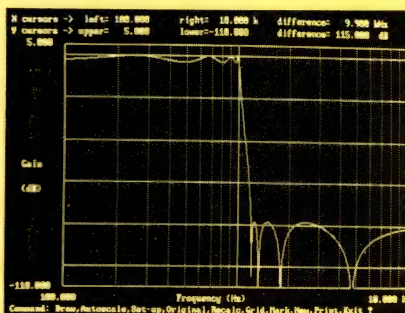
Mainframe PCB layout features for your PC... + **FREE**, ongoing, 1-800 support... + our 30 Day Money Back Guarantee!



FREE DEMO KIT
1-800-553-9119

O-MATION

CIRCLE NO 772



AFD - ADVANCED ACTIVE FILTER DESIGN SOFTWARE

Version 3.1 designs Lowpass, Highpass, Bandpass, Bandstop and Allpass filters with Butterworth, Chebyshev, elliptic and Bessel response. Calculates values and sensitivities for MFB, VCVS, biquad, state variable, National MF-10 and Reticon circuits. Interactive graphics for group or phase delay, gain, phase, impulse and step response of the complete filter or individual section. Combine filters for system design/analysis. Modify circuits to observe effects. For IBM PC, XT, AT, PS/2 (\$725).

* * * FREE DEMO DISK AVAILABLE * * *
FILE CONVERSION FOR SPICE, TOUCHSTONE
& NETOPT AVAILABLE

RLM Research

P.O. Box 3630, Boulder, CO 80307-3630 (303) 499-7566

CIRCLE NO 773

Jameco JE680 Universal IC Programmer

Programs PROMs, EPROMs, EEPROMs, PALs, GALs, RALs, EPLDs and PEELs

JE680 Features:

- Stand-alone or computer controlled modes w/ MS-DOS menu-driven software (included)
- Parallel and RS232C interface ports
- Auto-Sense™ of IC insertion
- Supports/translates between 18 data formats
- Full functional test on logic devices
- Over 400 IC definitions in ROM - no personality modules needed
- JEDEC standard supported, accepting input from virtually all major software packages
- One-Year Warranty

Listing of over 400 programmable devices and 74-page catalog available upon request!

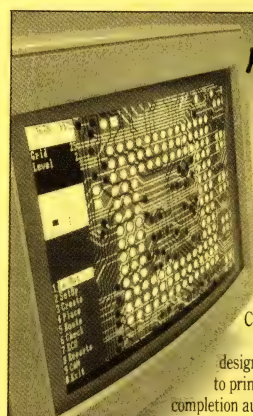


JE680 Universal IC Programmer\$1799.95

Jameco Electronics • 1355 Shoreway Road, Belmont CA 94002
• Phone (415) 592-8097 • FAX (415) 592-2503

CIRCLE NO 774

presenting PADS SUPERSTATION for TOTAL INTEGRATION



Obtain complete cradle-to-grave performance from your personal computer CAD system when performing electronic packaging design. From schematic capture to printed circuit design, to 100% completion autorouting capabilities, it's all here. Now you have one more reason you should be using PADS: Total Integration. Call our Sales Hotline today to receive a free Integrated Evaluation Package for the PADS-SUPERSTATION.

Call Your Local Authorized Dealer

CAD

Software, Inc.
119 Russell St.
Littleton, MA 01460

In MA: (508) 486-8929
Outside MA: (800) 255-7814

CIRCLE NO 775

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

BUSINESS/CORPORATE STAFF

Peter D Coley
VP/Publisher
Newton, MA 02158
(617) 964-3030; Telex 940573
Ora Dunbar, Assistant/Sales Coordinator

Mark J Holdreith
Advertising Sales Director
Newton, MA 02158
(617) 964-3030
Heather McElkenny, Assistant

Deborah Virtue
Business Director
Newton, MA 02158
(617) 964-3030

NEW ENGLAND
Chris Platt, Regional Manager
Clint Baker, Regional Manager
199 Wells Ave
Newton, MA 02159
(617) 964-3730

STAMFORD 06904
George Isbell, Regional Manager
8 Stamford Forum, Box 10277
(203) 328-2580

NEW YORK, NY 10011
Daniel J Rowland, Regional Manager
249 West 17th St
(212) 463-6419

PHILADELPHIA AREA
Steve Farkas, Regional Manager
487 Devon Park Dr, Suite 206
Wayne, PA 19087
(215) 293-1212

CHICAGO AREA
Greg Anastos, Regional Manager
Jack Johnson, Regional Manager
Holly Gronset, Telemarketing
Cahners Plaza
1350 E Touhy Ave, Box 5080
Des Plaines, IL 60017
(312) 635-8800

DENVER 80206
John Huff, Regional Manager
44 Cook St
(303) 388-4511

DALLAS 75243
Don Ward, Regional Manager
9330 LBJ Freeway, Suite 1060
(214) 644-3683

SAN JOSE 95128
Walt Patstone, Regional Manager
Bill Klanke, Regional Manager
Philip J Branon, Regional Manager
James W Graham, Regional Manager
3031 Tisch Way, Suite 100
(408) 243-8838

LOS ANGELES 90064
Charles J Stillman, Jr
Regional Manager
12233 W Olympic Blvd
(213) 826-5818

ORANGE COUNTY/SAN DIEGO 92715
Jim McErlean, Regional Manager
18818 Teller Ave, Suite 170
Irvine, CA
(714) 851-9422

PORTLAND, OREGON 97221
Pat Dakin, Regional Manager
Walt Patstone, Regional Manager
1750 SW Skyline Blvd, Box 6
(503) 297-3382

UNITED KINGDOM/BENELUX
Jan Dawson, Regional Manager
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

SCANDINAVIA
Stuart Smith
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FRANCE/ITALY/SPAIN
Alasdair Melville
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

WEST GERMANY/SWITZERLAND/AUSTRIA
Wolfgang Richter
Sudring 53
7240 Horb/Neckar
West Germany
49-7451-7828; Telex: 765450

EASTERN BLOC
Uwe Kretschmar
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FAR EAST
Ed Schrader, General Manager
18818 Teller Ave, Suite 170
Irvine, CA 92715
(714) 851-9422; Telex: 183653

HONG KONG
John Byrne & Associates Ltd
1613 Hutchison House
10 HGarcourt Road
Central Hong Kong
Tel: 5-265474
Tlx: 61708 WEDIN HX
Fax: 5-8106781

JAPAN
Kaoru Hara
Dynaco International Inc
Suite 1003, Sun-Palace Shinjuku
8-12-1 Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan
Tel: (03) 366-8301
Telex: J2322609 DYNACO

KOREA
Kim Kyong-Hae, BK International
Won Chang Bldg, 3rd Floor 26-3
Yoido-dong, Youngdungpo-ku
Seoul 150, Korea
Tel: 785-6665; FAX: 784-1915
Telex: K32487 BIZKOR

**SINGAPORE/MALAYSIA/INDONESIA/THAILAND/
THE PHILIPPINES/AUSTRALIA/NEW ZEALAND**
Asia Pacific Media House PTE Ltd
Peter Cheong
100 Beach Rd
#24-03 Shaw Tower
Singapore 0718
Tel: 2915354; Telex: RS 50026 MESPLY

TAIWAN
Acteam International Marketing Corp
6F, No 43, Lane 13
Kwang Fu South Rd
Mailing Box 18-91
Taipei, Taiwan ROC
760-6209 or 760-6210
Telex: 29809; FAX: (02) 7604784

PRODUCT MART
Joanne Dorian, Manager
249 West 17th St
New York, NY 10011
(212) 463-6415

INFO CARDS
Donna Pono
Newton, MA 02158
(617) 558-4282

CAREER OPPORTUNITIES/CAREER NEWS
Roberta Renard, National Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068
(201) 228-8602

Janet O Penn, Eastern Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068
(201) 228-8610

Paula Compton, Western Sales Manager
18818 Teller Ave, Suite 170
Irvine, CA 92715
(714) 851-9422

Diane Philipbar, Sales Assistant
103 Eisenhower Parkway
Roseland, NJ 07068
(201) 228-8608

Wendy A Casella, Advertising/Contracts Coordinator
Nan E Coulter, Advertising/Contracts Coordinator
Aileen B Turner, Advertising/Contracts Coordinator
(617) 964-3030

William Platt, Senior Vice President, Reed Publishing USA

Cahners Magazine Division
Terry McDermott, President, Cahners Publishing Co
Frank Sibley, Senior Vice President/General Manager,
Boston Division
Tom Dellamaria, VP/Production & Manufacturing

Circulation
Denver, CO: (303) 388-4511
Eric Schmierer, Group Manager

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Joanne R Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (312) 635-8800.

EDN's CHARTER

EDN is written for professionals in the worldwide electronics industry who design, or manage the design of, products ranging from circuits to systems.

EDN provides accurate, detailed, and useful information about new technologies, products, design techniques, and careers.

EDN covers new and developing technologies to inform its readers of practical design matters that will be of concern to them at once or in the near future.

EDN covers new products

- that are immediately or imminently available for purchase
- that have technical data specified in enough detail to permit practical application
- for which accurate price information is available.

EDN's Magazine Edition also provides specific "how to" design information that its readers can use immediately. From time to time, EDN's technical editors undertake special "hands on" engineering projects that demonstrate EDN's commitment to readers' needs for useful design information.

EDN's News Edition also provides comprehensive analysis and news of technology, products, careers, and distribution.

EDN

275 Washington St
Newton, MA 02158
(617) 964-3030

Brooktree™

SEMICONDUCTOR INDUSTRY SAN DIEGO OPPORTUNITIES

Brooktree Corporation is the industry leader in data conversion IC's serving the computer graphics market and developer of other innovative products employing mixed signal technology. We currently have excellent career opportunities in the following areas:

MILITARY PRODUCT ENGINEER

Candidate in this position will be responsible for planning and carrying out development, and sustaining product engineering activities relating to our military product family. Duties include: conducting evaluation of Silicon (overall) circuit performance against design goals, using bench instrumentation and/or ATE, for the purpose of attaining design release; working with test engineering to ensure that the circuit is electrically tested correctly; performing electrical characterization for DC and AC parameters; defining specification and electrical test limits; developing an efficient manufacturing flow which will be used to produce the product with a minimum of overhead; and ensuring that all requirements for MIL-STD-883 are met.

The candidate we seek must have a BSEE or equivalent along with a minimum of three years' experience with military products.

PRODUCT MARKETING ENGINEER - MILITARY PRODUCTS

Candidate in this position will coordinate the qualifications and manufacture of military products through interaction with Design, Product and Test Engineering, Production Control, QA, Assembly, Packaging and other groups as necessary. You are responsible for the initial review of all customer specifications against Brooktree standard datasheets, and the recommendation of changes or further review by other organizations. You will also provide marketing support for the military program through datasheet generation with participation in the Standard Military Datasheet program, maintenance of product documentation, pricing, product availability and other similar efforts.

The selected candidate must have a BSEE or equivalent and four to eight years' experience with military components or systems at an engineering or product marketing level. You must have the skills to motivate, guide and persuade groups and individuals toward task accomplishments with a minimum of conflict as well as a familiarity with MIL-STD-883 and 38510 documents. The ability to identify problems, suggest solutions and implement solutions is required.

The Brooktree environment relies heavily on teamwork. Our culture is one of openness and sharing. You must be willing to accept and welcome input from anywhere in the organization.

Brooktree offers a highly competitive compensation and benefits package. If you possess the qualifications for either of these positions and would like to join a winning team, please submit your resume and salary history to: **BROOKTREE CORPORATION, Professional Staffing, 9950 Barnes Canyon Road, San Diego, CA 92121.** We are an Equal Opportunity Employer.

CAREER OPPORTUNITIES

1989 Editorial Calendar and Planning Guide

Issue Date	Recruitment Deadline	EDN Editorial Emphasis	EDN News Edition
Sept. 14	Aug. 24	Industrial Product Showcase, Digital ICs	Closing: Aug. 30 Mailing: Sept. 21
Sept. 28	Sept. 7	Integrated Circuits, Computer Peripherals	Closing: Sept. 15 Mailing: Oct. 5
Oct. 12	Sept. 21	DSP Chip Directory, Integrated Circuits	Closing: Sept. 28 Mailing: Oct. 19
Oct. 26	Oct. 5	Test & Measurement Special Issue Computers & Peripherals	Closing: Oct. 27 Mailing: Nov. 16
Nov. 9	Oct. 19	CAE, Integrated Circuits	Closing: Nov. 9 Mailing: Nov. 30
Nov. 23	Nov. 2	16th Annual $\mu P/\mu C$ Directory, Integrated Circuits	Closing: Nov. 22 Mailing: Dec. 14
Dec. 7	Nov. 16	Product Showcase — Volume I, Power Supplies	Closing: Nov. 22 Mailing: Dec. 14
Dec. 21	Nov. 30	Product Showcase — Volume II, Components	

Call today for recruitment advertising information:

East Coast: Janet O. Penn (201) 228-8610

West Coast: Paula Compton (714) 851-9422

National: Roberta Renard (201) 228-8602

Electronic Engineers,
Computer Scientists,
Aerospace Professionals:

You're Needed!

... at high tech companies in
New England and
nationwide.

Work with
Computer Science & Engineering

and enjoy these advantages:

- Immediate openings in rewarding positions
- Staffed by technical professionals
- Salary/benefit negotiations on your behalf
- Client companies who assume all fees

Submit your resume in confidence to:

Computer Science & Engineering

P.O. Box 1026 / Porter Sq.
Cambridge, MA 02140

First, there was the vision...



Space exploration began with a vision.

The fire of imagination—fused with superior technical proficiency—leading the way to limitless possibilities. A special vision that creates the kind of breakthroughs that characterize GE Astro Space. Since the nation's first space communications adventure nearly 30 years ago, GE Astro Space has been a world leader in the design and manufacture of satellites for government and commercial communications, meteorological, navigational and scientific use. And, with over one hundred and fifty satellites currently circling the globe—and long-term, history-making projects such as the *Space Station* and *Mars Observer*—we can offer Engineers the kind of rare opportunities that few are destined to realize.

Our mission requires the technical proficiency of degreed Engineers with a minimum of 3 years experience, specifically in the following areas:

- Propulsion Systems
- Launch Vehicle Integration
- Power Systems
- Spacecraft Attitude Control
- Spacecraft Harness Design
- Solar Arrays
- Electro-Optics
- Microwave/RF Design
- Antenna Mechanical Design
- Systems Integration & Test
- System Definition & Requirements
- System Safety Engineers
- Materials Engineers

Our New Jersey location offers all the advantages of nearby Princeton—within easy access to New York City and Philadelphia. Additionally, selected positions are open in historic Valley Forge, PA. In either location, you'll experience a lifestyle that complements your career, providing unlimited opportunities for personal and professional growth. As the largest employer of engineers and scientists in the world, GE provides competitive salaries and exceptional benefits including tuition refund and continuing education programs—so your expertise is always current and expanding. Rush your resume to: Employee Relations, Dept. EDNM, GE Astro Space, P.O. Box 800, Princeton, New Jersey 08543-0800.



GE Astro Space
Cross the engineering frontier.

An equal opportunity employer

Software Engineers

TRW's Command Support Division is the prime contractor on multiple large software contracts.

These include distributed command and control systems for U.S. and overseas locations, development of state-of-the-art workstations for overseas command center implementation, as well as related independent research and development projects.

We are looking for exceptional individuals with the talent, capability, and drive to enhance our team in one of the following areas:

Database Engineers

- Design and development experience using the relational data model
- Familiarity with database applications using Oracle, Informix or Sybase DBMS
- Expertise in the area of distributed data management
- Experience with database machines
- Familiarity with Ada/SQL binding

UNIX Software Development Engineers

- Unix System V/BSD system administration experience with SCCS/RCS

- MAKE and similar utilities
- HP-UX, ULTRIX experience
- C programming proficiency

Software Integration & Test Engineers

- Three to five years' software integration and test experience
- Expertise with DoD-STD-2167A and its methodology
- Some positions may require an EBI

Ada Prototype Engineers

- Three years' design/MMI experience
- Knowledge in prototype tools and techniques
- Positions range from entry level to management

Ada Software Engineers

- Extensive experience on at least one major Ada program
- Expertise with DoD-STD-2167A and its methodology
- Strong skills in object oriented design and development
- Positions range from entry level to middle management

Transition Engineers

- Transition (Honeywell to VAX) planning
- Site activation

These positions are based at our newly-built Federal Systems Park in Fairfax County, Virginia. We can offer highly competitive salaries. Our benefit plans are among the most attractive in the industry.

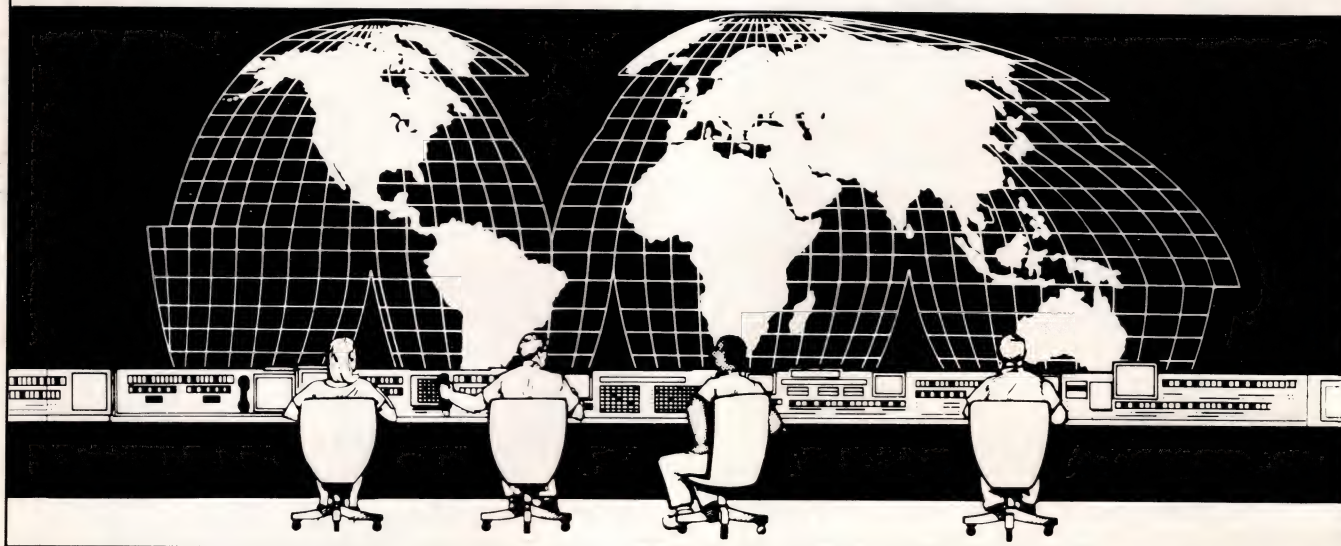
To be immediately considered, please send your resume to: Professional Placement, TRW Command Support Division, Department BB/30J, One Federal Systems Park Drive, FP2/6245, Fairfax, VA 22033.

An Equal Opportunity Employer
U.S. Citizenship May Be Required

**Tomorrow is Taking Shape
at a Company Called TRW.**

TRW

Command Support Division
TRW Federal Systems Group



Adventure & Discovery in Aerospace & Defense.

Engineering breakthrough. It's a process of exploration, of inspiration, and, finally, of triumph. It takes the right combination of technology and people. And, it's a way of life at Smiths Industries, SLI Avionic Systems Corporation.

We are one of the world's premier manufacturers of aircraft instruments, guidance and navigation systems. Building on a long history of leadership, we are today involved with numerous state-of-the-art technologies, including inertial reference systems, fiber optic gyros, flight data recorders and flight management systems.

As one of the pioneers in computerized flight management systems, we are utilizing powerful microprocessor architectures to increase their functional capability, reliability, and power consumption efficiency. The result is a state-of-the-art product line for flight plan management, navigation, performance management and guidance. Join us at our Grand Rapids Operation in one of the following areas.

RESEARCH & DEVELOPMENT

Challenges are available at all experience levels within our Advanced Development Organization. PhD or equivalent in EE, ME or Physics preferred. **Dept. #1A**

Technology development leadership challenge in the design and enhancement of fiber optic gyro products. PhD in EE or equivalent. **Dept. #1B**

AVIONIC SYSTEMS ENGINEERING

Avionic Systems Installation Engineering challenges require at least 2-10 years structural design and cockpit modification experience on military aircraft. BSME, BSAE or equivalent. International travel. **Dept. #2A**

Military Avionic Systems Engineering challenges require at least 3 years experience in military avionics, with emphasis on software-intensive systems. Ability to write operational and software requirement specs necessary; structured analysis and design methods experience preferred. BSEE or equivalent. **Dept. #2B**

CONFIGURATION/DATA MANAGEMENT

Configuration Management position requires 3+ years CM experience, preferably in a defense electronics environment. Also requires a working knowledge of DOD-STD-480 and MIL-STD-481, 482, 483, 490 and 1521. Must have experience with CM identification systems, and a familiarity with change proposals, deviation waivers and change control. **Dept. #3A**

Data Management position requires 3+ years DM experience, preferably in a defense electronics environment. Also requires a working knowledge of contracts composition, CDRLS, DIDS and SOW. You must have the ability to identify, interpret and evaluate data requirements, and to provide direction to data preparation projects. Your duties will include assuring data quality, and scheduling, monitoring and recording all data deliveries. **Dept. #3B**

Data Quality Specialist position requires minimum 6 years in data quality. Must know CDRL, SRDL, DID, MIL-STD's-483, 489A, 2167, 2167A and MIL-Q-9858A. **Dept. #3C**

SYSTEMS PROGRAMMING

Programmer Analyst positions available for manufacturing engineering support and administrative/financial control applications. BS in Computer Science or equivalent. Experience with IBM mainframe, IBM PC, & DEC VAX utilizing OS, AIX/UNIX*, PC-DOS, & VMS desirable. **Dept. #4A**

SOFTWARE ENGINEERING

Section Manager in Support Systems Development position available. Experience with VAX/VMS and UNIX* operating systems helpful. Proven management skills and BS or MSCS in Math or Physics or the equivalent required. **Dept. #5A**

Challenges available through the management level for engineers experienced in the development of avionic real-time software. Knowledge of Kalman filters, inertial navigation, estimation theory and mathematical analysis necessary. BS or MS in EE, ME, AE or equivalent. **Dept. #5B**

Requires 5+ years experience in real-time embedded, computer-based system requirements specification, architecture design, functional design and programming. Familiarity with DEC VAX/VMX environments and formal development methods is essential. Knowledge of CASE tools and teaching/training experience also needed. MSCS, MSEE or equivalent. **Dept. #5C**

Requires 5+ years experience in development and test of real-time software for microprocessor applications. Any of the following helpful: Fortran; ADA; Motorola 68000 or Intel 8086 assembly languages; inertial navigation principles; strapdown technology. BSEE, BSCS or equivalent. **Dept. #5D**

Experience in real-time avionic systems/software development required; MIL-STD-1750A processor and Jovial experience preferred. MSCS, BSEE or equivalent. **Dept. #5E**



Requires experience in: estimation theory; inertial navigation; strapdown systems; reduction and analysis of data from inertial navigation system flight tests. Degree or equivalent. **Dept. #5F**

TEST SOFTWARE DEVELOPMENT ENGINEERING

Requires 3+ years experience writing test software for avionic system hardware, with a background in digital circuitry. Knowledge of structured analysis/design necessary, with knowledge of 3 or more of the following: Fortran, C, Jovial Assembly, Atlas, Basic. Design and test experience preferred. BSEE or equivalent. **Dept. #6A**

SIMULATIONS & ANALYSIS ENGINEERING

Requires 5+ years experience in advanced control systems, Kalman filters, systems modeling and mathematical analysis. Advanced degree in Physics, Math, EE or ME or equivalent. **Dept. #7A**

HARDWARE DESIGN ENGINEERING

Requires 5+ years experience to include: project management in gyro, IMU or sensor development; systems design; analog and digital hardware design. BSEE or equivalent. **Dept. #8A**

Analog Power Supply Design Engineering challenge requires 3+ years experience in Switch mode power supply design and familiarity with military requirements. BSEE or equivalent. **Dept. #8B**

Hybrid Microcircuit Design Engineering challenge requires experience in product design coordination, hybrid development and fabrication, and CAD. **Dept. #8C**

MANUFACTURING ENGINEERING

Positions are available at several levels, for Engineers with experience in one of the following: PWB fabrication and assembly, wave solder, vapor phase, and wire bonding; optical sensor process techniques. **Dept. #9A**

QUALITY ENGINEERING

Component Quality Design position available for those experienced in FMEAs and reliability, or in the selection and specification of subassemblies and PWB's. BS in EE, ME, Physics or equivalent required. **Dept. #10A**

Assembly, Program and Procurement Quality positions available requiring experience in electromechanical assemblies, or military avionic systems. BSEE, BSME or equivalent. **Dept. #10B**

MARKETING

Marketing Manager for Inertial Reference Systems position requires an experienced marketing professional to manage product line activities. These include plan development and implementation, forecasting, customer contact, proposal management and closing the sale. Responsibilities would include inertial reference systems marketing to DOD organizations and aircraft and missile primes. Should be knowledgeable with DOD organization, funding and procurement practices. Looking for a motivated marketing and sales person with some technical background. **Dept. #11A**

Marketing Manager with 10 years experience marketing avionics products to the air transport manufacturers and major airlines. Engineering or related degree, pilot experience helpful. **Dept. #11B**

Smiths Industries offers a salary and benefits package you'd expect from a leader. We will provide relocation assistance to our attractive community in western Michigan, which offers a below-average cost-of-living and proximity to endless recreational activities. For consideration, forward your resume and salary history, indicating the position in which you are interested, to:

Judy Percy
Manager of Technical & Professional Staffing
SMITHS INDUSTRIES

SLI Avionic Systems Corporation
Grand Rapids Operation
4141 Eastern Ave., SE
Grand Rapids, MI 49518-8727

*UNIX is a trademark of Bell Labs.



Equal Opportunity/Affirmative Action Employer



If Engineering is your strong suit, here's a chance to contribute to ours!

When you think of Hamilton Standard, you probably think of our space suits and the place they've earned in history. Just like our propellers and flight controls, or our prop fans of the future that are literally history in the making.

If you're a Mechanical or Electrical Engineer, Hamilton Standard can offer you hands-on involvement on projects that will challenge your expertise—and reward your contributions! To qualify, you must have a Bachelor's degree and a desire to advance in a growth-oriented environment.

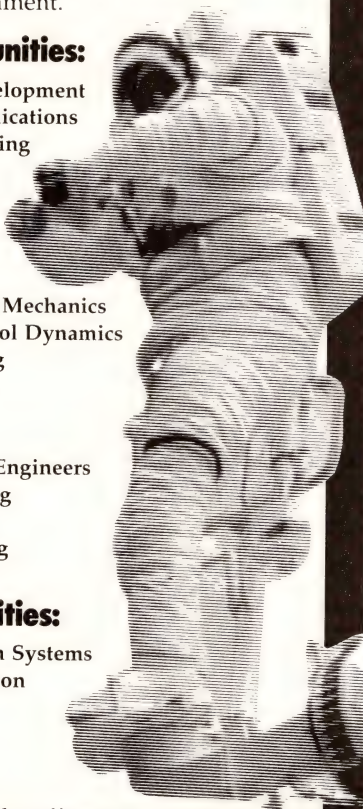
Engineering Opportunities:

- ☐ Technical Software Development
- ☐ Embedded Avionic Applications
- ☐ Manufacturing Engineering
- ☐ Mechanical Design
- ☐ Project Engineering
- ☐ Chemical Engineering
- ☐ Materials Engineering
- ☐ Artificial Intelligence
- ☐ Rocket Propulsion/Fluid Mechanics
- ☐ Thermo Dynamics/Control Dynamics & Analytical Engineering
- ☐ EMI Nuclear Hardness
- ☐ Electrical Design
- ☐ Systems Engineering
- ☐ Guidance & Navigation Engineers
- ☐ Metallurgical Engineering
- ☐ Reliability Engineering
- ☐ Electro-Optic Engineering
- ☐ Industrial Engineering

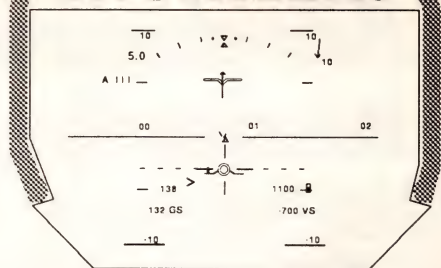
Additional Opportunities:

- ☐ Management Information Systems
- ☐ Subcontract Administration
- ☐ Finance & Accounting
- ☐ Plant Engineering
- ☐ Technical Marketing

Qualified candidates will be offered an excellent salary/benefits package and liberal relocation assistance to our attractive central Connecticut location. If you're ready to make history, please send your resume and area of interest to: Mr. Jeff Odell, Professional Recruitment, Dept. EDM, Hamilton Standard, One Hamilton Road, Windsor Locks, CT 06096. An equal opportunity employer.



ENGINEERS



Flight Dynamics Inc. Portland, Oregon

Flight Dynamics, Inc., a leader in head-up guidance systems using state of the art holographics and avionics technology, is growing - FAST. Our system is currently the only one that has FAA certification for Category IIIA weather conditions, and is operational in Alaska Airlines 727's. The recent announcement of three new contracts stretching over several years demonstrates the growing acceptance of the FDI system and establishes the foundation for our aggressive expansion into and through the 90's. These projects include Canadair on an OEM basis, Federal Express european certification of the F27, and Lockheed in the development of the P7A (LRACCA).

We need engineers in several disciplines to join us as we continue to apply our technology to new aircraft and markets - commercial, corporate and military. Responsibilities will include new aircraft type certifications (OEM and retrofit), product development and enhancement, and support of current installations.

SYSTEMS/FLIGHT CONTROLS ENGINEERS

Minimum qualifications include a Bachelor's degree in aeronautical, electrical, or mechanical engineering and experience in one or more of the following areas: flight test, data acquisition, simulation, control law synthesis and design, autopilot/flight director performance analysis, FAA certification, safety analysis (per MIL-STD-882) or reliability engineering.

ELECTRICAL ENGINEERS

Minimum qualifications include a BSEE with 3-5 years experience in a structured design environment preferred. Desired design experience includes real time microprocessor based hardware, ARINC 429 and 1553 bus structures, analog/digital I/O, and BIT.

MECHANICAL ENGINEERS

Minimum qualifications include a BSME, 6 years experience in the design/development of aircraft equipment, including experience in small component stress and thermal analysis, materials and processes, and a knowledge of environmental requirements. Project leadership experience desired.

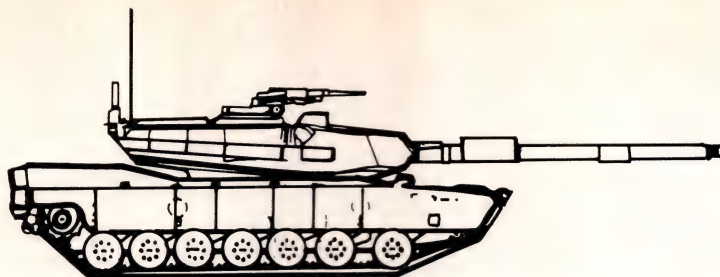
SOFTWARE ENGINEERS

Minimum qualifications include a BSEE or BSCS degree and 3-5 years experience. Desired background includes real time systems development, use of structured design and documentation techniques, microprocessor hardware and interface knowledge, and formal software verification experience. Project leadership experience desired.

MECHANICAL DESIGNERS

Minimum qualifications include an AA degree or equivalent and 5 years experience in the design/development and packaging of avionics equipment. Must be familiar with Military or FAA specifications, geometric tolerancing, casting and sheet metal design, and 3-D CAD (CV preferred).

Ideally located in the heart of the majestic Pacific Northwest, Portland offers a multitude of recreational activities as well as reasonable housing, excellent schooling, and diverse cultural activities. We offer exceptional challenges, advancement potential, and a competitive compensation package. Send your resume, in confidence, identifying the position you are applying for on the envelope to: **FLIGHT DYNAMICS, INC., P.O. Box 230609, Portland, OR 97223.** We are an Equal Opportunity Employer.



DON'T FOLLOW IN THE TRACKS OF OTHERS...

At General Dynamics Land Systems Division you can chart your own course for success. Advancing technologies and rigorous program schedules involved in the evolution of the M1A1 Main Battle Tank require the expertise of a wide range of disciplines. Choose the area which best suits your interests and background:

SOFTWARE ENGINEERING

- Experience with MIL-STD-2167A
- VAX/UNIX Environment
- Ada, C and Pascal necessary

ELECTRO-OPTICAL ENGINEERING

- Experience in Fourier Optics, Holographic Filters, Phase Conjugation necessary

ELECTRONIC DEVELOPMENT ENGINEERING

- Experience with MIL-STD-1553B and hardware/software interface requirements necessary
- Digital/Analog Design preferred
- 68000 Microprocessor Application; VME Backplane

ARTIFICIAL INTELLIGENCE

- Knowledge-based system development
- Machine vision
- Diagnostics & Prognostics

SIMULATION TEST ENGINEERING

- Pascal, C, Fortran and experience in the development of real-time software to support simulation application required

SOFTWARE QUALITY ASSURANCE

- Experience with MIL-STD-2167
- Software Development in Ada
- Experience in Quality Assurance, Software Quality Test or Configuration Management

The above opportunities require a BS, MS or PhD in a related discipline and 3 to 15 years' experience.

RELIABILITY ENGINEER

- 1-5 years' experience in problem identification and resolution
- Knowledge of Computer Data Management
- Digital background and experience in predictions and FMECA preferred
- BSEE or BSET required for this position

OPERATIONS RESEARCH ANALYSTS

- Experience in Systems Modeling and Simulation
- Knowledge of multiple criteria decision making techniques
- 3-5 years' experience in Math Modeling

- BS degree in Engineering, Computer Science or Math
- Master's degree preferred

SYSTEMS ANALYSIS ENGINEER

- 1-2 years' experience with emphasis on Math, Physics, Computer
- Infrared, Radar, Acoustic, Visual Millimeter wave signature analysis
- Susceptibility modeling to determine probabilities of detection, acquisition, and bit
- Ballistic and non-ballistic vehicle vulnerability using BRL vulnerability methodology

We offer an excellent compensation program and a full range of benefits including relocation assistance, tuition refund, computer purchase assistance, stock investment plans and complete family medical and dental plans as well.

For immediate consideration, send your resume and salary requirements, to: **Manager, Professional Staffing, General Dynamics Land Systems Division, P.O. Box 2072, MZ 436-11-34, Drawer 220, Warren, MI 48090.**

GENERAL DYNAMICS
Land Systems Division

An Equal Opportunity Employer



SPEAK TO THE FUTURE

The world we live in has become an increasingly mobile one. Communication has become increasingly mobile too, and **GTE**

Mobile Communications is committed to responding to this rapidly growing market.

We have become an industry leader providing products and services throughout the United States. And when we speak to the future, the message is very clear: **The power is on at GTE.**

If you wish to become a part of a fast-paced, innovative company, let's talk!

DESIGN AND APPLICATIONS ENGINEERS—HOUSTON, TEXAS

We're looking for highly-skilled engineering professionals to design, create, and develop new mobile cellular products, services and hardware/software applications at our corporate headquarters in Houston, Texas. Requirements include:

- BSEE preferred; BSCS, systems engineering or equivalent experience in radio equipment design desirable
- Five years of experience in cellular mobile telephone or radio-based technology
- Extensive experience with microprocessors or microcontrollers
- Fluency in "C" under UNIX and DOS; PL/M and ASSEMBLER
- Strong experience in either digital signal processing or large-scale integration or artificial intelligence

In Houston, you'll discover unparalleled opportunities for a quality lifestyle — incredibly affordable housing, year-round outdoor recreation, and a vast array of entertainment and cultural activities. And at **GTE Mobile Communications**, we offer a high-energy environment, competitive salaries and comprehensive benefits.

So, let's talk and speak about your future today! Just **CALL OUR 24 HOUR/7 DAYS PER WEEK TOLL-FREE NUMBER LISTED BELOW** to learn more about our current opportunities. Or, contact us at: **GTE Mobile Communications, 616 FM 1960 West, Suite 400, Houston, Texas 77090.** We are an equal opportunity employer M/F/H/V.

1-800-221-3333

Ext. GTE

CALL TODAY OR ANYTIME

GTE Mobile
Communications

THE POWER IS ON

M
I
C
R
O
-
R
E
L

IC DESIGN ENGINEERS Phoenix Metropolitan Area

Innovation, dedication, reliability . . . they're all critical in the microelectronics industry. At Micro-Rel, we've aggressively met the most complex needs of industry for over 16 years. Now, we're ready for even more far reaching success in the 1990's and beyond.

We are currently seeking analytical individuals with a BSEE, at least 5 years experience and a proven design background in Bipolar, CMOS or BiCMOS technologies to create analog IC designs.

These and other current technical positions are available in our IC and Hybrid areas. Please send your resume in confidence to: **Micro-Rel, Dept. EDN8179, 2343 W. 10th Place, Tempe, AZ 85281.**

Medtronic  **Micro-Rel**

Equal Opportunity Employer

If You're Looking For a Job, You've Come to The Right Place.

EDN CAREER OPPORTUNITIES

EDN

YOUR WORK AREA IS 131 MILLION SQUARE MILES OF OCEAN

And your opportunities at Lockheed in Marine Systems are just as vast. Located just 45 miles south of San Francisco, Lockheed is a leader in the development of underwater vehicles and ASW systems. We're expanding our operations and are in need of highly qualified professionals in the following areas of expertise to join our top-notch design team.

Mechanical Design

Power Systems

Guidance and Control

Sensor Systems


Systems Integration

Test Engineering

Software Development

All positions require a BS degree in an appropriate discipline and 2+ years' related experience.

Come join us and explore the depths of Lockheed Missiles & Space Company's programs. Send your resume to M. Santucci, Professional Staffing, Lockheed Missiles & Space Company, Dept. 551LGMC, P.O. Box 3504, Sunnyvale, CA 94088-3504. We are proud to be an equal opportunity, affirmative action employer. U.S. citizenship required. Current EBI preferred.

 **Lockheed Missiles & Space Company**
Innovation
Giving shape to imagination.

Join the software team that's making naval history.

FULL SPEED AHEAD. Computer Sciences Corporation shares the Navy's deep commitment to the development of the Seawolf class of submarines and the AEGIS weapons systems. These vital projects have already been funded by the government. But they can't be completed without you on board. So, we're seeking software experts to design and develop some of the most sophisticated and advanced systems in the world. We're looking for the best talent in the industry to help carry on CSC's tradition of excellence and history of achievement in developing all kinds of military information systems. The Seawolf project has outstanding opportunities at our Bryn Athyn, PA and Moorestown, NJ facilities for:

- Software Engineers
- Software Systems Designers
- Submarine Combat Systems Engineers
- Ada Professionals
- Real-Time Command & Control Systems Engineers
- Application Programmers



Computer Sciences Corporation

Opportunities exist for individuals with experience in any of the following areas to work on the AEGIS weapons systems at our Moorestown, NJ facility:

- Scientific Applications
- Process Control
- Military Applications
- Simulation/Stimulation
- I/O Systems
- Inter-Computer Communications
- Radar or Acoustic Signal Processing

Programmer Analysts and Computer Scientists will also need experience in the following:

- Software Hardware Configuration
- ULTRA CMS CS-1
- Software Test & Integration
- Systems Integration
- Software Quality Assurance
- VAX 11/780, AN/UYK Series
- Operating Systems/Executive

Find out more about the options that could enrich your career. Exercise your expertise on some of the most dynamic and sophisticated Navy programs available today. Send a copy of your resume, indicating position of interest, to: **Mike Baker, Computer Sciences Corporation, Integrated Systems Division, Dept. EDNM, 304 W. Route 38, P.O. Box N, Moorestown, NJ 08057.** An Equal Opportunity Employer.

Ada Ada Ada

We research/find Ada careers with full SW lifecycles, methods, CASE tools, Sun/Rat. workstations, mature SW Eng. cultures, training, interesting realtime-embedded applics. DoD/Commercial. Current Locations: AZ CA CO FL IN OH MA MD NC NJ NM NY RI TX VA WA and Nationwide. \$35-70k Call.

1-800-367-8882

PAUL MORRIS PERSONNEL

1040 N.Kings Hwy. Suite #625
Cherry Hill, N.J. 08034

Knock, Knock.

In EDN's Magazine and News Editions, opportunity knocks all the time.

EDN Magazine Edition News Edition

Quality of Technology Sets Us Apart.

Leonardo Da Vinci's exceptional foresight enabled him to make discoveries and achievements in the broad-based areas of art and engineering. Today, the Da Vinci spirit is thriving at Fortune-100 Raytheon, where vision is combined with diverse technical expertise to advance quality technology beyond current boundaries.

Raytheon's Missile Systems Laboratories has created many of today's most sophisticated air defense systems including HAWK, PATRIOT, Maverick and Sparrow. Due to continued expansion and anticipated new business, we seek engineering professionals for our Tewksbury and Bedford, MA laboratories.

Electro-Optics Laboratory

The Electro-Optics Laboratory has primary responsibility for the design and development of advanced infrared and visible missile seekers, IR search and track systems, fuzes, and related technologies. Projects involve design, analysis, integration and test of electro optical systems.

- Simulation & Algorithm Development • IR Systems Design & Development • Optical Design

Systems Design Laboratory

This group synthesizes, analyzes and evaluates system concepts and configurations, defining mission and performance requirements at the system level, and establishing hardware and software design requirements at the subsystem level. We also design guidance and control systems, model systems elements, and predict their performance and cost, as well as validate system designs and integration by means of real-time, hardware-in-the-loop simulation and pre- and post-flight analysis.

- Advanced Weapon System Analysis • Hardware-in-the-loop Simulation • Guidance Control • NCTR Development • Radar Signal Processing Analysis

Software Laboratory

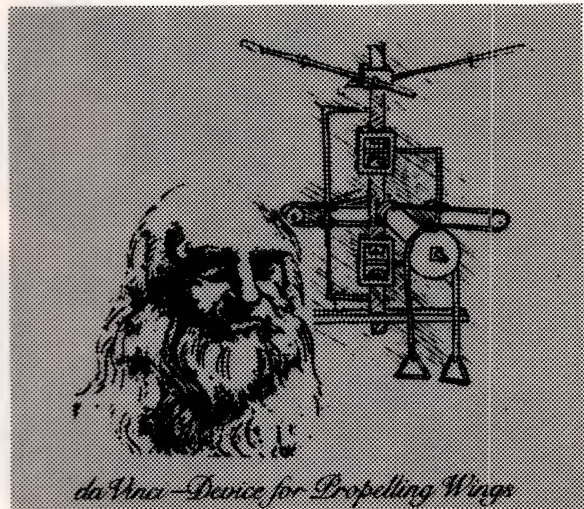
The Responsibilities of this lab include the design and development of computer software, and the management and operations of various scientific computer facilities. The lab is involved in a variety of projects requiring a diversity of technical skill areas which include surveillance, command and control, missile guidance, real-time, executive control, data collection/reduction, simulation, signal processors, diagnostics, software tools, UNIX® and support software development.

- UNIX & C Knowledge • Ada Development • Software Application Design, Code, Test & Integration • Hardware & Software Evaluation/ Test • Familiarity with VAX, VMS & ULTRIX

Radar Systems Laboratory

Radar Systems is responsible for the overall design and development of ground and airborne radar systems. Development activities involve wideband adaptive antennas, millimeter wave and microwave solid state technologies, integration and test systems, receivers, signal processors and high speed control units.

- Analog/Digital Control Circuit Design for Radar Exciters • Production Support Engineering • High-voltage Power Supply Design/Development



Missile Guidance Laboratory

Here, Engineers are responsible for the design and development of Raytheon's highly successful RF guided missiles. This is a total commitment, extending beyond the labs into flight tests and evaluation, and ultimately to production and deployment. All aspects of electrical engineering are required, providing an excellent diversity of technical challenges in a single organization.

- Control Systems • Autopilot Design • Analog Circuit Design • MMIC & Millimeter Wave Design

Test Systems Operation

The Test Systems Operation team is responsible for the development of test systems and software to be used at all program stages from development, through production, to depot test. Test equipment spans all levels of hardware, from circuit cards to systems, and including analog, digital and RF. This group also performs testability reviews for hardware under development, as well as providing on-site support to the factory to resolve test related problems.

- Digital & Analog Interface Circuit Design/Development • Test Software Design & Development

The positions range from entry to Senior level and require a BS in EE, Physics or Math.

We offer competitive salaries, liberal relocation allowances, and many company-paid benefits including a 401(k) and tuition assistance programs. Please send resume with salary requirements to:

Raytheon Company, Missile Systems Laboratories, Attn: Employment Manager, Dept. EDM, 50 Apple Hill Drive, Tewksbury, MA 01876-0901. An Equal Opportunity Employer.

UNIX® is a registered trademark of AT&T Bell Laboratories.

Raytheon

Where quality starts with fundamentals.

TEST DRIVE YOUR RESUME.

Tune up your resume, bring it to BPI TECH FAIR and watch it perform.

You'll meet recruiters and top line management from the nation's top technical companies. You'll discover fresh, new professional challenges. And you'll learn what you're *really* worth in today's job market.

Representatives from leading corporations will be on hand to interview qualified candidates at the following BPI TECH FAIR locations:

August 14-15, Huntsville Marriott, Huntsville, AL
August 21-22, Wichita Marriott, Wichita, KS
August 28-29, Boston Marriott, Burlington, MA
September 11-12, Houston, TX
September 18, Columbia, MD
September 19-20, Washington, DC
September 25-26, Denver, CO
September 27, Colorado Springs, CO
October 2-3, Dallas, TX
October 16-17, Los Angeles, CA

October 18, Woodland Hills, CA
October 23-24, Minneapolis, MN
November 7, Milwaukee, WI
November 8-9, Chicago, IL
November 13-14, Boston, MA
November 15, Braintree, MA
November 20-21, Washington, DC
December 4, Ft. Lauderdale, FL
December 5, Melbourne, FL
December 6, Orlando, FL

So come to the next BPI TECH FAIR in your area. It's the job fair that puts you in the driver's seat.

TECH FAIR[®]
THE NATION'S #1 JOB FAIR FOR ENGINEERING, SYSTEMS & SOFTWARE DEVELOPMENT PROFESSIONALS



• 2985 Multifoods Tower • 33 South Sixth Street • Minneapolis, MN 55402 • (612) 370-0550



DESIGNING YOUR FUTURE...TODAY

Sverdrup Corporation is a prominent engineering firm in the weapon system development and aerospace technical services contract areas. Discover what we have accomplished in our 60 years of experience, and consider our opportunities in high tech design and analysis!

In anticipation of increased technical staff requirements associated with the TEAS contract at Eglin Air Force Base, Florida, we seek expressions of interest in employment from the following engineering and scientific professionals (MS or PhD + 2 or more years related experience):

ENGINEERS

- Aerospace
- Aircraft/Weapon Integration
- Artificial Intelligence
- Guidance & Control
- Materials
- R&D Manufacturing/producibility
- Reliability/Quality
- RF/Electronic Warfare
- Seeker
- Simulation
- Systems

ANALYSTS

- Air Operations
- Missile
- Mission Planning
- Radar
- Scientific/Database Programmers
- Structural
- Systems
- Thermal
- Threat
- Vibration
- Weapon System

The TEAS Group provides Technical and Engineering Acquisition Support of conventional weapon systems development for the Air Force Systems Command/Munitions Systems Division. Eglin AFB, Florida is by Ft. Walton Beach, near sugar white beaches on the Gulf of Mexico. This area offers diversified recreation, a high-caliber school system and very affordable housing. Sverdrup/TEAS offers employees a competitive benefits and relocation package.

Qualified applicants are invited to send a complete resume with salary requirements in strict confidence to:

Val Strobel
Manager, Human Resources
SVERDRUP/TEAS
P.O. Box 1935, Dept T-131
Eglin Air Force Base, FL 32542

An Equal Opportunity Employer M/F/H/V

EDN Magazine Edition News Edition **Databank** Professional Profile

Announcing a new placement service for professional engineers!

To help you advance your career, Placement Services, Ltd. has formed the EDN Career News Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- It's absolutely free. There are no fees or charges.
- The computer never forgets. When your type of job comes up, it remembers you're qualified.

- Service is nationwide. You'll be considered for openings across the U.S. by PSL and its affiliated offices.
- Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.
- Your background and career objective will periodically be reviewed with you by a PSL professional placement person.

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you knew about it. That's why it makes sense for you to register with the EDN Career News Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

IDENTITY		PRESENT OR MOST RECENT EMPLOYER			
Name _____		Parent Company _____			
Home Address _____		Your division or subsidiary _____			
City _____	State _____	Zip _____		Location (City, State) _____	
Home Phone (include area code) _____		Business Phone (if O.K. to use) _____			
EDUCATION					
Degree (List) _____	Major Field _____	GPA _____	Year Degree Earned _____	College or University _____	
EXPERIENCE					
Duties and Accomplishments _____		Present or Most Recent Position _____	From _____	To _____	Title _____
Industry of Current Employer _____					
Reason for Change _____					

POSITION DESIRED					
Job Title _____					
Employer _____	From _____	To _____	City _____	State _____	
Division _____	Type of Industry _____		Salary _____		
Duties and Accomplishments _____					
COMPENSATION / PERSONAL INFORMATION					
Years Experience _____	Base Salary _____	Commission _____	Bonus _____	Total Compensation _____	Min. Compensation _____
Date Available _____	I Will Travel <input type="checkbox"/> Light <input type="checkbox"/> Moderate <input type="checkbox"/> Heavy		I own my home/appt. <input type="checkbox"/>		
<input type="checkbox"/> Employed <input type="checkbox"/> Self Employed <input type="checkbox"/> Unemployed	<input type="checkbox"/> Married <input type="checkbox"/> Single		Height _____	Weight _____	
Level of Security Clearance _____		<input type="checkbox"/> U.S. Citizen <input type="checkbox"/> Non-U.S. Citizen		My identity may be released to: <input type="checkbox"/> Any employer <input type="checkbox"/> All but present employer	
<input type="checkbox"/> WILL RELOCATE		<input type="checkbox"/> WILL NOT RELOCATE		<input type="checkbox"/> OTHER _____	

EDN Magazine Edition News Edition **Databank** A DIVISION OF PLACEMENT SERVICES LTD., INC.

265 S. Main Street, Akron, OH 44308 216/762-0279

EDN's INTERNATIONAL ADVERTISERS INDEX

Abbott Transistor Laboratories Inc	238	IOtech Inc	221	Sophia Systems Inc	115
ACCEL Technologies Inc	257	ITT ElectroMechanical Components Worldwide	18-19	Sprague Electric Co	79
Actel	54-55	Jameco Electronics	260	Standard Research Systems Inc	77
Advanced Analog	166	John Fluke Manufacturing Co Inc* . 20, 159-162		STC Components Ltd	169
Advanced Micro Devices	12-13, 56-57	Jonathan Mfg	212	STD Mfg Group	217
Advin Systems	259	Kemet Electronics	251	Stimpson Co Inc	64
Aerospace Optics Inc	45	Kepeco Inc	231-232	Sun Electronic Systems Inc	42
AMP	150	Kontron Elec	170	Sunrise Electronics Inc	228, 259
Amphenol	200	Korry Electronics	93	Tatum Labs	258
Amphenol Canada Corp	216	L-Com Inc	260	T-Cubed Systems Inc	259
Anaheim Automation	198	Lemo USA Inc	257, 259	Tektronix Inc	117
Annabooks	256	Linear Technology Corp	190	Teledyne Solid State	201
Applied Microsystems Corp	181, 182, 180-183	Logical Advances	260	Texas Instruments Inc	48, 68-71, 69-70 139-142
Arnold Magnetics Corp	167	Logical Devices Inc	72, 255	Themis Computer	150
AT&T Technologies	223	Logical Systems Corp	256	Thomas Electronics Inc	226
Avantek	221	Marconi Instruments Inc	146	Tokim Corp	127
Avocet Systems Inc	186	Marshall	185	Toshiba America Inc	36, 46-47, 254
Ballard Technology	258	Maxim Integrated Products	121-122	Transera	239
Baystat	255	Measurement Systems Inc	197	United Technologies	243
B&C Microsystems	257, 259	Mentor Graphics Corp	6	Universal Data Systems	C3
BKC International Electronics	42, 250	Meridian	204	UPS	119
Bomco	44	Micrel	253	Versatec	203
BP Microsystems	258	Micro Crystal Div/SMH	260	Vicor	123
Bradford Electronics	33	Micro Computer Specialties Inc	257	Vishay	218
Brooktree Corp	202	Minc	234	VLSI Technology Inc	66-67
Buckeye Stamping Co	255	Mini-Circuits Laboratories	3, 4, 26, 27, 195	Volgen America	230
BV Engineering	257	Molex Inc	276	WinSystems Inc	256
Bytek Corp	250, 258	Motorola Semiconductor Products Inc	32, 113	Wintek Corp	258, 260
Caddock Electronics Inc	100	M S Kennedy Corp	92	Xeltek	259
CAD Software Inc	260	Murata Erie North America Inc	C4	Xentek	244
Cahners Exposition Group	165	MWS Wire Industries	210	Yeti	198
Cahners CAPS	86	National Instruments	2	Zax Corp	128
Calcomp	143	NEC Corp	188-189	Zilog Inc	199
California Eastern Labs Inc	224	NCI	256		
Capital Equipment Corp	258	NCR Microelectronics Div	235		
Chips and Technologies	135, 137	Nicolet Test Instruments Div	249		
Clinton Electronics	184	NMB Technologies	25		
Communication Specialists	256	Nohau Corp	255		
Cybernetic Micro Systems	256	Octagon Systems	257		
Cypress Semiconductor	23	OKI Semiconductor	28-29		
Dale Electronics Inc	1	Omaton Inc	260		
Data I/O Corp	8, 259	Orbit Semiconductor	192		
Datakey	208	OrCAD Systems Corp	179		
Du Pont Connector Systems	144-145	Orion Instruments	58		
Eagle Picher	236	Philips Circuit Assemblies	220		
Eastman Kodak	187	Philips T&M	37, 99		
Eaton Corp	255, 260	Phillips Components Inc	259		
EDAK Inc	206	Pioneer Magnetics	237		
E F Johnson	226	PLX Technology	35		
EG&G Almond Inst	34	Powertec	120		
Elantec	245	Powertech Inc	242		
Electroswitch Corp	219	Precision Interconnect	94		
Electronic Designs Inc	148	Precision Monolithics Inc	14-15		
Emcor Products	252	Protel	43		
Emerson & Cuming Inc	168	Pulizzi Engineering	255		
E-T-A Circuit Breakers	258	Pulse Instruments	248		
Force Computers Inc	30-31	Qua Tech Inc	256, 258		
Franklin Software Inc	257	Racal-Redac	44		
Frequency Devices	211	Radstone Technology	207		
Fujitsu Limited	246	Rantec Power Systems	233		
GCOM Inc	242	Raytheon	63		
General Semiconductor Industries Inc	217, 219, 221	Ready Systems	124-125		
Hall-Mark	91	RLC Enterprises	258		
Harris Semiconductor	16-17	RLM Research	260		
Hewlett-Packard Co	50-53, 51-52, 87-88, 89, 213, 215	Rockwell International	229		
Hitachi America Ltd	98-99	Rogers Corp	147, 259		
Hoffman Engineering	149	S-Cubed	253		
Honeywell Test Instrument Div	126	Science Accessories	95		
Hybricon Inc	257	Seeq Technology Inc	36-39		
ICI Imagedata	209	Sepox Corp	226		
ILC Data Device Corp	90	SGS-Thomson Microelectronics*	36-37, 40-41		
Inmos	10-11	Siemens AG	20		
Integrated Device Technology Inc	65	Signetics Corp	101		
Intel Corp	80-81, 82-83, 84-85	Silicon Systems Inc	225		
Intusoft	256	Skydyne	240		
		Songtech	256		
		Sony Corp of America	97		

Recruitment Advertising 262-273

Brooktree Corp
Computer Science and Engineering
Computer Sciences Corp/Integrated Systems Div
Flight Dynamics
GE AstroSpace
General Dynamics/Land Systems Div
GTE Mobile Communications
Lockheed Missiles and Space Co
Paul Morris Personnel
Raytheon Missile Systems Div
Smiths Industries
Sverdrup Technology
TRW/Command Support Div
United Technologies/Hamilton Standard

*Advertiser in US edition

**Advertiser in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

Commitment to Technology

Magazine Edition

The electronics industry's leading design publication

News Edition

The electronics industry's only technical newspaper



EDN Magazine
Edition
News
Edition

A Partnership in Power and Prestige Worldwide

Molex Is Making The Connection Between...

FLEXIBILITY & APPLIED COST

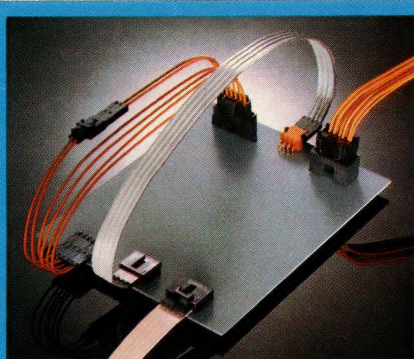
Get the design flexibility you want at the price you need with Molex's unique C-Grid SL™ connector system.

Molex's C-Grid SL system of connectors was designed especially for automated wire termination, modular interconnection, and robotic placement.

The SL line features fully stackable components including single piece IDT connectors, crimp contacts and housings, shrouded headers, and panel mount housings and clips. Connector styles include modular, low profile, polarized, and polarized with positive latching.

This broad line of products combined with our unique packaging and automated delivery systems make Molex's C-Grid SL line of connectors an innovative, hard-working answer for engineers looking to achieve their designs at the optimum cost.

For your free samples and our full-line catalog, contact us today.



There's a C-Grid SL connector for all your wire-to-wire, board-to-board, and ribbon cable-to-board needs.

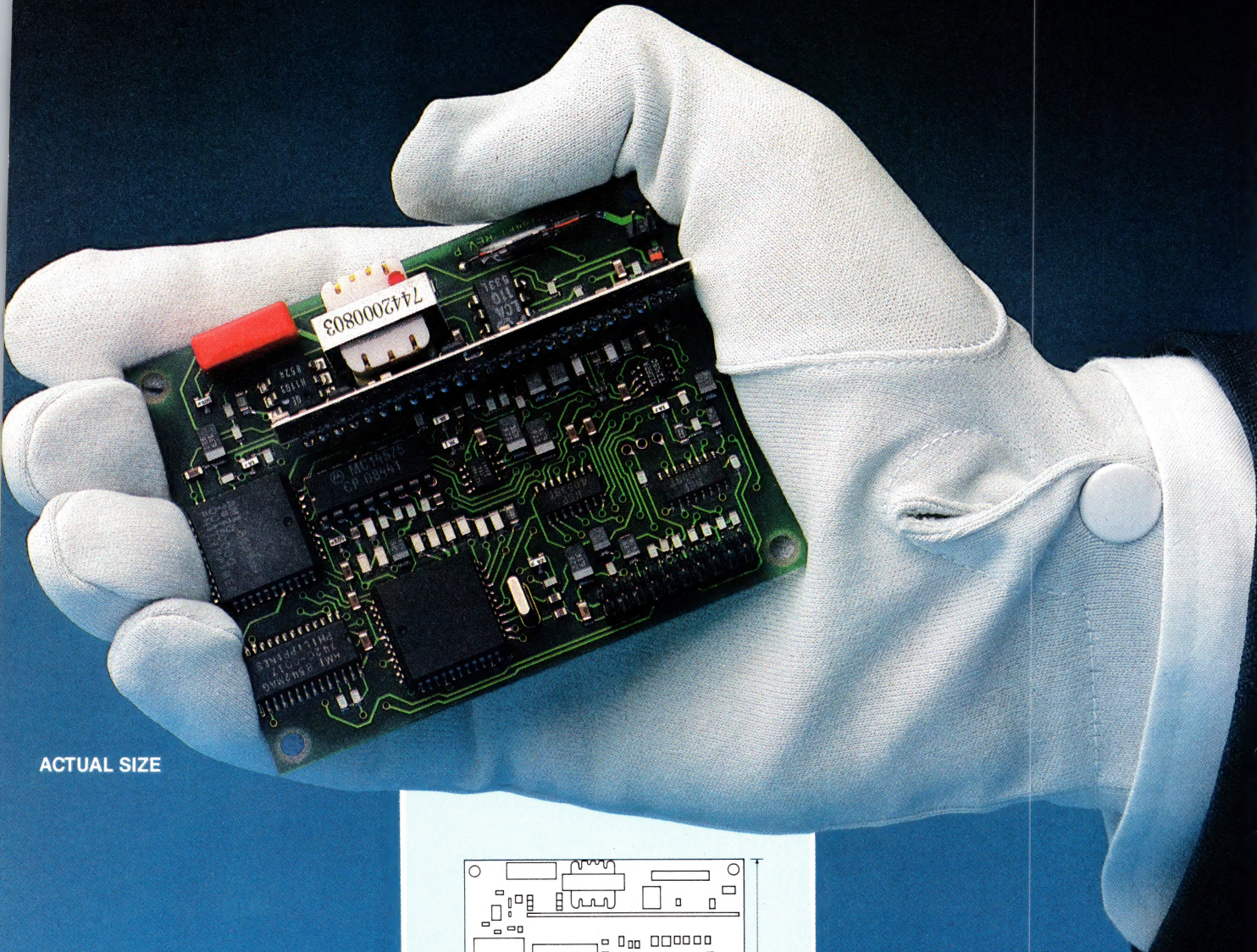
The dual row IDT connector... the only coverless dual row connector available today.



*Service To The
Customer... Worldwide*

Corporate Headquarters: 2222 Wellington Ct., Lisle, IL, 60532 USA, 312-969-4550 • European Headquarters: Munich, West Germany, 49-89-496093
Northern Asia Headquarters: Tokyo, Japan, 03-487-8333 • Southeast Asia Headquarters: Jurong Town, Singapore, 65-265-4755

MODEM DESIGN ELEGANCE AT 2400 BPS

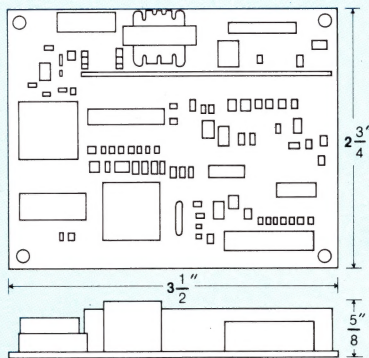


ACTUAL SIZE

A FULLY FEATURED V.22 *bis* ON 9.6 SQ. IN.

At Universal Data Systems, surface-mount technology has brought a new level of engineering elegance to V.22 *bis* modem design. Using a combination of LSI and surface mounting techniques, we're now able to fit a *fully featured* V.22 or V.22 *bis* on 9.6 sq. in. of board space.

And when we say fully featured, we *mean* fully featured. Requiring +5 and $\pm 12V$ to operate, this superminiature device has the same auto-dial, auto-answer, audio driver, line diagnostic and self-test features formerly found only on larger, heavier, more power-hungry and more expensive V.22s.



It's available now in a standard configuration, ready for internal mounting in the new terminal, microcomputer or other data communications device you're designing.

To be sure you're getting a true fully featured device at a most

attractive price, contact UDS for detailed specifications. Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35807-7002. Telephone 205/721-8000; FAX 205/721-8926.



Universal Data Systems



MOTOROLA INC.
Information Systems Group

CIRCLE NO 163

Created by Dayner/Hall, Inc., Winter Park, Florida

What's new in chip capacitors?

There's one sure way to find out—Murata Erie. Because we've led the way in chip capacitor technology from the beginning. And we're still at it.

Take size. We go small in a big way. Who else can give you chip capacitors as minuscule in size as 1.0mm x 0.5mm.

On the other hand, we've taken capacitor values up—to our highest ever—our GR250 Series and its full 10 μ F, 16V capacity in an 8.0mm x 6.3mm x 2.7mm package.

We've also developed ways to boost your productivity. Tape packaging, for example, that—using 2mm pitch—gives you twice as many chips on a reel. And bulk chip capacitor magazines that increase the efficiency of auto-placement equipment.

You should know, however, we're still not satisfied—even while shipping 2.5 billion capacitors a month. There's work to be done, more breakthroughs to be made. And we're staying on the job, in traditional Murata Erie style.

So you can remain certain that, when something's new in chip capacitors, you'll hear from us first.

For technical assistance, write or call Murata Erie North America, 1900 West College Avenue, State College, PA 16801, 814-237-1431. For literature or for the location of your local Murata Erie Distributor or Sales office call 1-800-356-7584.



MURATA ERIE NORTH AMERICA

CIRCLE NO 162

